ERS-301

ORGANIZING and OPERATING DRYLAND FARMS in the Great Plains

Summary of Regional Research Project GP-2

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Economic Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
In cooperation with the
Agricultural Experiment Stations of
Kansas, Montana, Nebraska, North Dakota, Oklahoma, and Texas

FOREWORD

In July 1958, the regional research project "Organizing and Operating Dryland Farms in the Great Plains to Meet Variable Climatic and Economic Conditions" (GP-2) was approved for 5 years by the Great Plains Research Committee of the Great Plains Agricultural Council. Six State agricultural experiment stations and the Economic Research Service had contributing projects. Results of the research under these projects have been published in more than 35 separate bulletins, circulars, professional journal articles and papers, not counting leaflets and extension releases. A workshop was held in May 1959 on management strategies in Great Plains farming, and a symposium on economic problems of livestock ranching was held in May 1962. The papers and discussions of both the workshop and the symposium have been published by the Council.

In 1963, the Great Plains Research Committee extended the life of the regional project 1 year. The purpose was to complete work underway and to review progress and accomplishments as a basis for extending or revising the project. The job of making the summary review was assigned to Warren R. Bailey, committee member for the Economic Research Service. He was assisted by all members having contributing projects. His draft report was accepted by the Great Plains Research Committee at its meeting in July 1964, with the recommendation that it be published. This is that report.

This publication serves another important purpose. Some persons have questioned whether GP-2, a collection of contributing projects each pursuing different aspects of the problem, truly constitutes a regional project. The report confirms that it does. All of the contributing projects examined and described the problem of year-to-year variability, and each explored one or more of nine managerial strategies as possible solutions.

The regional project outline has been revised and approved with a new focus and a new title, "Economics of Establishment, Survival, and Growth of Dryland Farms in the Great Plains Environment." Early work was on strategies for farm business survival in an environment of uncertain yields. The emphasis was on year-to-year variability of production and income of a farm viewed as a static entity, a farm of a given size and investment. The new focus considers the farm firm as a growing business over time. The question of maximizing income in a setting of growth is different and more realistic than in a static setting.

GP-2 is an outstanding example of coordination and cooperation among professional researchers from different institutions having common problems.

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ACKNOWLEDGMENTS

Committee members provided copies of their project work plans and of their publications, reports, and papers, and they gave unstintingly of their time and energies in answering questions, tracing sources of data and in reviewing the manuscript. Dr. D. C. Myrick, Farm Production Economics Division, ERS, offered many helpful suggestions and prepared some of the publication abstracts found in the appendix. This enthusiastic cooperation added greatly to the completeness and quality of the report.

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(June 1965)

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SUMMARY

Certain strategies can help dryland farmers cope with or reduce year-to-year variations in yield and income. This was the major finding of regional research project, GP-2, to which six agricultural experiment stations--Montana, North Dakota, Nebraska, Kansas, Oklahoma, and Texas--and the Economic Research Service contributed research projects.

The main economic problems were thought to stem from the very large year-to-year variation in farm income and production, so all projects were planned to measure an aspect of variability and to discover ways of reducing it. Variations in acre yields and in income were found to be greatest among the dryland crops--wheat, grain sorghum, barley, and soybeans--which also had higher-than-average income per acre. Variability was greater in grain crops than in forage crops, and was about the same in forage crops and livestock. Yield varied less than gross income because it also includes price variations. Gross income varied relatively less than net income.

One strategy for the farm firm is to select only those enterprises having low year-to-year variability, such as forage crops and livestock. However, these enterprises also produce low average returns to land and to other inputs. Hence, this is not the best strategy for the firm having land suitable for grain. Choice of enterprises can also affect the firm's rate of growth.

Another strategy is to combine enterprises having different patterns of year-to-year variability. For example, grain sorghum and winter wheat have different growing seasons. When these crops are grown in combination, yield and income vary less than for each crop alone. Also, combinations of grain crops and forages and combinations of grain crops and livestock enterprises showed less variation than the grain crops alone. While combining enterprises does reduce income variability, it does this only with some sacrifice in total income.

Flexibility is a strategy for coping with seasonal variability in the range-livestock enterprise. It means the ability to adjust livestock numbers to fluctuations in range forage. When forage expands, flexibility is achieved by keeping more of the calf crop for another season of grazing, by growing more breeding herd replacements, by culling less severely than usual, and by buying stocker steers. When forage declines, the adjustment is accomplished by selling more of the calf crop, by growing fewer breeding herd replacements, and by culling the herd more heavily than usual. The cow-calf enterprise, with its large cow herd, has the greatest capacity for expansion. The cow-yearling enterprise, with its smaller cow herd, is the easiest to contract. A combination cow-calf-yearling enterprise has built-in two-way flexibility.

Using feed reserves is a strategy that can both reduce year-to-year fluctuations in livestock output due to fluctuations in range forage, and complement the strategy of flexible range-livestock systems. The strategy is to harvest and store some forage during periods of abundance for use in periods of drought. But when the drought arrives, an economic problem arises: The hay reserves are then high in value due to general scarcity, whereas the cattle are relatively low in value because everyone is selling. It may be more profitable to sell the hay reserves, even though that

requires selling some of the cattle. A system of hay reserves and constant herd size produced lower average net returns than a system without reserves and fluctuating cattle numbers. Thus, stability was again achieved at some sacrifice of income.

Using financial reserves is a strategy for coping with year-to-year fluctuations in income. Reserves may be in the form of bank balances, corporation stock, bonds, and so on. Although financial reserves can earn interest or dividends, they usually represent an opportunity cost to the farm firm. The funds in reserve could otherwise be invested in a productive enterprise on the farm.

Spatial diversification is a strategy for reducing year-to-year variability in a farm's total output and income. Noncontiguous fields dispersed over a wide area are unlikely to all experience a timely shower, a destructive hail, or a sapping drought the same crop year. Results of the study confirmed this hypothesis. Greater dispersion was required for small farms than for large ones.

Crop insurance is a strategy for coping with the income effects of natural hazards such as drought, hail, insect damage, and so on. All of these risks are covered in the all-risk insurance of the Federal Crop Insurance Corporation. Crop-hail insurance is available from commercial insurance companies. The study indicated that many farmers carried both the FCIC all-risk insurance and commercial hail insurance. FCIC insurance was more popular among farmers who had become eligible for reduced rates. Crop-hail insurance was favored when crop prospects were good.

Improved production technologies may serve as managerial strategies to cope with production risks. For example, fertilization may increase or decrease efficiency in use of soil water by vegetative plants. Studies in GP-2 showed that plant response varied with soil moisture at planting time and with seasonal rainfall.

Irrigation is a strategy for stabilizing crop yields in the Plains. Studies indicated that irrigation reduced year-to-year variability by about half; some of the variability in the Plains is evidently not due to rainfall. While irrigation does reduce yield variability, the studies indicated that the return per dollar invested in irrigation was much less than the rate of return to dryland crops.

In general, GP-2 studies show that most management strategies that reduced year-to-year variability of output or income, also reduced the average or longrun income. Thus, greater stability comes at some opportunity cost to the firm. This poses the question: How much is stability worth to the firm? Is it worth giving up opportunities for business growth? Inasmuch as large firms are better able to cope with risk, maybe rapid growth is a feasible and desirable strategy. These are some of the questions and hypotheses that will continue to be studied in the revised regional research project, GP-2.

ORGANIZING AND OPERATING DRYLAND FARMS IN THE GREAT PLAINS
Summary of Regional Research Project GP-2

By Warren R. Bailey
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INTRODUCTION

How best to organize and operate dryland farms in the Great Plains has been a persistent problem that has occupied the thoughts and energy of generations of farmers. It has been studied specifically and directly by economists and other scientists. But the problem of organizing and operating farms in a variable climate has not been studied before in such a concerted fashion as under the GP-2 regional research project. The problem is larger and more complex than was realized 5 years ago. Yet much has been learned in GP-2 about yield and income variability in Great Plains farming. The purpose of this report is to summarize and evaluate what we have learned as a basis for outlining further research work and, hopefully, a fresh approach.

The report is arranged in two parts. Part I briefly describes the regional project--its objectives, procedures, and work planned--followed by a summary of the main research results. Part II discusses each contributing project in turn--the problems studied, the objectives, the work planned, and what was accomplished. There is a list of contributing publications arranged as a bibliography, followed by the appendix, which contains abstracts of selected research publications stemming from the contributing projects.

PART I. THE REGIONAL PROJECT AND RESEARCH RESULTS

Objectives

The goal as seen was information that would aid dryland farmers in organizing and managing their farms. Researchers would need to study the major resource and management situations of the region. They would determine the income level and variability of farm enterprises individually and in combinations. And they would examine and test various management strategies farmers might use in organizing and operating their farms to achieve their income goals. The research generally would focus on the problem of year-to-year variability in production and income and the means of reducing that variability, as farmers undertake other adjustment problems.

Outlined Procedures

Research procedures in the regional project were outlined in three phases. Phase I would assemble the necessary primary and secondary data for representative farm situations. Data would include resources, input-output relationships, and costs and

returns by enterprises and by farming systems. Phase II would analyze enterprises and their combinations. Phase III would evaluate various strategies farmers might use in securing business survival and in accumulating capital. Strategies considered, but not in all cases undertaken, were:

(1) Institutional arrangements. Postulate changes in property taxes, land tenure, and bank credit arrangements, and estimate their effect on different groups of farms over time.

(2) Production technologies. Consult with scientists and review promising new technologies and appraise technological impacts singly and in combination for different farming situations.

(3) Enterprise choice. Estimate the expected effect of different enterprise combinations on financial survival and capital accumulation under alternative weather and economic conditions.

(4) Flexible livestock systems. Determine the expected impact of flexible strategy on discounted costs and incomes, capital accumulation, and the high and low extremes of income.

(5) Feed reserves. Through a series of budgets over time for different farm situations, estimate the effect of feed reserves on discounted costs and incomes, and on capital accumulation.

(6) Off-farm employment. Analyze the impact on financial survival and capital accumulation of farmers having different equity positions.

(7) Contract farming. Explore the impact on fixed and variable costs and on the level and variability of income.

(8) Financial management. Explore the implications of the following strategies:

(a) Use of annual income above nondeferrable costs (e.g. adjustments in family living, depreciation and replacement of capital items, surplus reinvestment, and financial reserves).

(b) Management of capital in the firm (use of credit and management of equities).

(c) Stabilization of income (use of insurance, financial and commodity reserves, tax management, and resource organization and scale).

(9) Spatial diversification. Analyze the year-to-year variability of total production and income over time of farms composed of contiguous fields, and farms having fields separated various distances from the base unit.

Contributing Projects

Six State experiment stations and the Economic Research Service have had contributing research projects, each touching on one or more of the specific objectives of the regional project.

Montana chose to study spatial diversification as a management strategy. Would a farm composed of fields separated by several miles experience more steady average production over time than a farm having contiguous fields? Would operating costs be increased?

North Dakota was interested in the relative variability of different enterprises and the possible stabilizing effect of irrigating a field or two on an otherwise dryland farm.

Kansas decided to study the strategies of enterprise choice, improved technology, contract farming, and off-farm work, each as a means of stabilizing income.

Nebraska, Oklahoma, and Texas designed their projects to compare the level and variability of alternative enterprises alone and in combination, and see what other strategies of management might be useful in achieving farm business survival and capital accumulation.

The Economic Research Service chose to study financial and capital management strategies adapted to the Plains environment. How could bank (and merchant) credit and crop insurance be used in harmony with carryover reserves, with repair and replacement schedules for machinery, with flexible livestock systems, and with other strategies to achieve income and stability goals? Basic to the question would be a knowledge of crop yield variability and patterns.

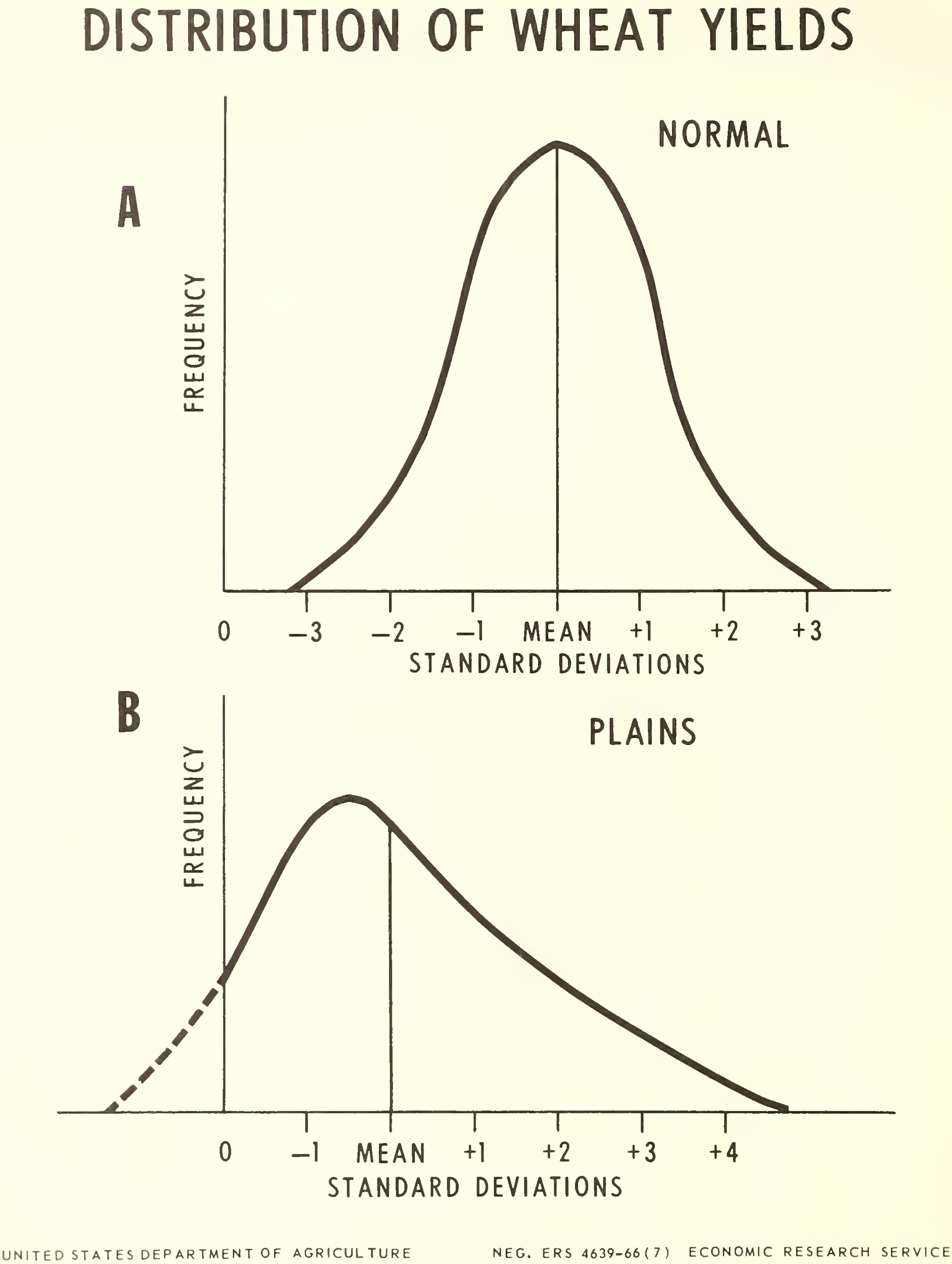
Summarized here under appropriate problem headings is what we learned in the contributing projects. Each research result is identified with the station and the research worker or leader, but not with a publication.

Variability of Yields and Income

To maximize his income, a farmer needs to know which crops return the most profit over the long run. Farmers concerned about stability of annual income also need to know which crops have the greater year-to-year variability of income. Income, of course, depends upon both the yield and the market price received, each of which may vary, often in opposite directions. That is, a large crop may sell for low prices and a small crop sell for high prices. While yield is commonly regarded as the main variable in the Plains, some studies under GP-2 also included the variability of price and income.

Year-to-year variability usually is described and measured in terms of annual deviations around the average--or mean. Shown graphically, the frequencies of yield observations typically resemble a bell-shaped curve as in figure 1-A. Such a distribution can be described statistically by computing the variance, the standard deviation, the coefficient of variation, and the range. These measures collectively describe the distribution and its variability rather well if the distribution is "normal." In the Plains, the frequencies of annual crop yields are typically distributed more like the curve in figure 1-B.

Because annual yields can fall to zero but not below, the curve is shifted to the left and is truncated. This truncation tends to reduce the measures of variability. Because an occasional yield can be very high the curve skews to the right.


DISTRIBUTION OF WHEAT YIELDS
A
NORMAL
FREQUENCY
0
−3
−2
−1
MEAN
+1
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STANDARD DEVIATIONS
B
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+1
+2
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+4
STANDARD DEVIATIONS
UNITED STATES DEPARTMENT OF AGRICULTURE
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ECONOMIC RESEARCH SERVICE

Figure 1

Consequently a few exceptionally high annual yields--those far above the mean--can have a greater influence on the measures of variability than the zero yields which are those usually associated with farming risk. Despite this limitation, the standard measures of variability about the mean are useful. Let us describe them briefly by means of an illustration.

Consider the hypothetical case of crops A, B, C, and D, which produced the following yields per acre in 11 years:

Year	Crop A	Crop B	Crop C	Crop D
1	10	20	10	0.5
2	15	30	20	1.0
3	20	40	30	1.5
4	15	30	20	1.0
5	10	20	10	.5
6	15	30	20	1.0
7	20	40	30	1.5
8	15	30	20	1.0
9	10	20	10	.5
10	15	30	20	1.0
11	20	40	30	1.5
Total------------------------------	165	330	220	11.0
Average-------------------------	15.00 bu.	30.00 bu.	20.00 bu.	1.0 ton
Standard deviation---------------	3.87 bu.	7.75 bu.	7.75 bu.	.387 ton
Absolute variance (SD^2)----------	15.00 bu.	60.00 bu.	60.00 bu.	.15 ~~1.5~~ tons
Coefficient of variation---------	25.8 pct.	25.8 pct.	38.7 pct.	~~25.8~~ 38.7 pct.

Variance (standard deviation squared) measures the absolute variation in bushels or tons, and is sensitive to the yield level of a crop. The coefficient of variation (C.V., standard deviation divided by the mean) measures the relative variability, hence is useful in comparing crops (or counties) having different yield levels, or crops having different production units--bushels versus tons.

In the illustration, crops A and B have different average yields, and different absolute variability (variance), but the same relative variability. Crops B and C have different yield levels, the same absolute variability, but different relative variability. Crop D (which might be alfalfa) has the same relative variability as crop A (which might be wheat) or crop B (which might be barley or grain sorghum).

These measures of variability applied to yields are equally useful when applied to gross income, net income, or net returns per dollar of all costs.1/

1/ E. Lloyd Barber studied the relative variability of wheat yields for each county for 1926-48. Variability of Wheat Yields, by Counties in the United States. E. Lloyd Barber, U. S. Dept. Agr., Bur. Agr. Econ., Washington, D.C., Sept. 1951.

North Dakota

In North Dakota, Schaffner found that irrigated crop yields in 1931-59 averaged about twice the corresponding dryland yields of wheat, barley, and alfalfa; about two and one-half times the dryland yield of oats; and about three times that of corn silage (23). 2/

Among the dryland crops, year-to-year variability was nearly a half larger for wheat and barley (C. V. about 45 percent) than for corn silage and alfalfa hay (C. V. about 30 percent). Among the irrigated crops, yield variability was also higher for wheat and barley (C. V. about 25 percent) than for alfalfa hay (C. V. 14 percent). Thus irrigation reduced the yield variability of wheat, barley, and corn silage by about 40 percent, and of alfalfa about 50 percent. Significantly, irrigation did not eliminate all of the year-to-year variability in crop yields--only about half of it.

Incomes from crop enterprises varied more from year to year than the yields, because incomes were also subject to price variability. Variability in gross income was greater in dryland crops than in irrigated crops, greater in cash crops than forage crops, about the same for forage crops and livestock, and greater for net cash income than for gross income. Year-to-year variability was greater for gross income than for return per $100 of all costs, and was least for net return per $100 of all costs.

Finally, Schaffner found that irrigation of the usual combination of wheat, oats, barley, corn, and alfalfa would:

Increase stability of production by 44 percent.
Increase stability of gross income by 14 percent.
Increase stability of net income by 18 percent.
Increase returns per $100 of all costs by 24 percent.

He found that none of the crops grown under irrigation showed cycles in gross income.

Nebraska

Finley studied income variability of 5 crops in 41 eastern Nebraska counties (11). Using annual county average yields and prices for 1943-58, he computed the variance and the coefficient of variation of the gross income per acre for each crop in each county. No area averages were computed. The range among the counties in average gross income, variance, and coefficient of variation were as follows:

Crop	Gross income (dollars)	Variance (dollars)	Coefficient (percent)
Corn	29-54	95-336	24-43
Soybeans	40-49	161-321	27-41
Wheat	35-47	133-324	29-41
Grain sorghum	24-32	90-159	27-53
Oats	15-22	18-42	21-37

2/ Underscored numbers in parentheses refer to Selected References Relating to Project GP-2, p. 48.

The high-income crops (corn, soybeans, wheat) tended to have higher absolute variability (as measured by variance) but lower relative variability (coefficients) than a lower return crop such as grain sorghum. Oats, the very low-return crop, of course ranked low in both absolute and relative variability.

In Kimball County, western Nebraska, much the same relationship between high-return and low-return crops was found. However, the coefficients of variation were much higher (averaging around 60-70 percent) than in eastern Nebraska (25-40 percent).

Kansas

Orazem studied the variability of crop yields and its cause in 29 western counties during the 41 years, 1916-56 (32). He computed variances due to type-of-farming area, county, and year. The chief variable was found to be "year," with its component variables: varieties, dates of planting, rainfall, hail, insect damage, and other hazards. Half the variability due to "year" was in rainfall. Because differences in average yields of adjacent counties were small, he concluded that spatial diversification would not reduce the year-to-year variability of a farm's total output in Kansas. Analysis of individual farm yields, with their greater variability, might show different results.

Orazem analyzed the effect of soil moisture, seasonal rainfall, and fertilization on grain sorghum yields on sandy soils in southwestern Kansas. He found that soil moisture had more effect than seasonal rainfall on yield. Yield response to nitrogen was positive, but it varied with moisture conditions. Response to phosphorus was negligible under all moisture conditions. Predicted yields per acre were as follows:

With soil moist to--	Seasonal rainfall	Nitrogen applied	Yield per acre was--
24 inches	2 inches	None	6.6 bushels
60 inches	8 inches	90 pounds	47.8 bushels

About 12 bushels of the higher yield was due to fertilizer (about 7.5 pounds of nitrogen per bushel). The first increments of nitrogen had the larger effect.

Oklahoma

For 1942-57, Greve found that in northwest Oklahoma (12) the variability (coefficient of variation) among the chief farm enterprises was as follows:

	Production	Net returns above cash costs
	Percent	
Grain sorghum	51.6	64.9
Wheat	33.1	43.2
Stocker steers	22.9	70.2
Cow-calf (variable herd values)	4.2	77.5

Note that the grain crops were more variable in production but less variable in income than the cattle enterprises. Apparently the variations in price offset the variations in production to a greater degree for cattle than for grain crops. If we assume constant herd values, the income variability of the cow-calf enterprise would fall to 37.9 percent, about half that of the stocker-steer enterprise.

These results cast some doubt on the traditional view that beef-raising enterprises are more stable sources of income than grain enterprises. Beef-raising, perhaps, has acquired its reputation for stability through faulty accounting. When drought comes, and grain crops fail to produce anything worth harvesting, the grainfields are used for grazing (a salvage operation) or are replanted to emergency forage crops. In a severe drought, feed supplies are so short that the entire farm (even public roadways) may be used to sustain the cattle. Consequently, cattle production may not fall appreciably that year, whereas the grain crops may show zero output. Thus, the cattle enterprise makes an apparently better showing, merely because it is given additional resources. When confined to its own land base (as it was in the Oklahoma analyses just discussed) the cattle enterprise appears more variable. The Great Plains cattle enterprise achieves its apparent stability because grain crops are also grown, hence grainland is a resource in reserve in time of drought. Because of this, the cattle may "fare" better on grain farms than on specialized ranches during periods of drought.

Greve's tests for bunchiness were significant for each of three test-runs, 4-year moving averages, and nonparametric statistical tests. 3/ Incomes tended to bunch more than yields. Grain sorghum yields tended to bunch more than other yields, both at yields less than 85 percent and above 115 percent of average.

In the Rolling Plains, Aanderud found that beef turnoff (hundredweight of cattle sold) was nearly twice as large and four to six times as variable for the stocker-steer enterprise as for the cow-calf, depending upon the type of forage grazed (3). Turnoff was highest (but variability was relatively low) on spring-pastured wheat (March-May). Average turnoff was higher on Johnsongrass and Sudangrass than on native range, but variability was higher only on the Sudangrass.

Aanderud studied the economic competition of forage livestock grazing enterprises and cash crops on large and small general farms, large and small range units, and large crop farms. He found the same competitive relationships in each farming situation. Each farm would grow its allotted acres of wheat (priced at $1.67). When the cattle enterprise was restricted to cow-calf, each farm would grow its wheat on fallow and would grow grain sorghum in a 3-year rotation. Then, the remaining cropland would produce pasture and harvested forage to supplement the native range for the cow-calf enterprise. However, if a stocker-steer enterprise is permitted, all cropland beyond the wheat allotment (no fallow) would produce pasture and forage to supplement the native range, and the livestock enterprise would be stocker steers. In fact, gross returns of the farm were higher with a steer than with a cow-calf operation, as follows:

3/ Tests for bunchiness are statistical measures of the degree to which groupings in observed data exceed what could be expected in random distributions (12)

Small general farm	+45 percent
Small range unit	+60 percent
Large general farm	+33 percent
Large range unit	+67 percent
Large crop unit	+27 percent

Texas

Johnson and Tefertiller studied the income variability of dryland cotton and grain sorghum in the High Plains and Rolling Plains (16). As data, they used yield records for a 30-year period at the Lubbock Experiment Station, and constant prices and costs. Their estimates of net income per acre and variability were:

	Cotton	Grain sorghum
Mean (dollars)	37.18	16.40
Variance (dollars)	547.06	143.94
Standard deviation (dollars)	23.39	11.98
Coefficient of variation (percent)	62.9	73.5

Note: Cotton had the higher net income per acre and the higher absolute variance, but the lower relative variability (coefficient of variation).

Nonparametric statistical tests showed evidence of regularly recurring cycles in the cotton series, but little such evidence was found in the grain-sorghum yield and reinvestment income with constant prices. However, considerable evidence of bunchiness (or year-to-year persistence) was found in both the grain-sorghum yield and the income data with constant prices.

Economic Research Service (Montana)

Bostwick found that farm yields varied more than county yields, which are useful in estimating farm yields over time, but greatly understate the true year-to-year variability of an individual farm (5). However, time-series data for individual farm yields are scarce. Bostwick found approximate farm-yield series in the form of official lease records of State-owned land in Montana dating back to 1939. Farms typically had coefficients of variation in wheat yields of 30 to 70 percent, whereas county yields had coefficients about half that large. A crop-insurance specialist has told the author that farm yields vary about 25 percent more than county yields.

Bostwick also concerned himself with the probability of a farm obtaining an extreme yield, either high or low. To this question he applied the extreme value theory of statistical distributions, based on the concept of accumulated probabilities (5). A mathematical equation expresses the probability that any one observation will be less than, or more than, a specified amount, when drawn from an experience distribution. Bostwick used this theory and equation to estimate the probability that a farmer in a given year would obtain a wheat yield sufficient to cover specified farm and family-living expenses. He did this for five sizes of farms in each of two areas. With these results, a farmer could predict which expenses he could reasonably expect to meet every year and which one he might not meet every year.

In the course of this work, Bostwick found that variability of wheat yields decreased as the farm's wheat acreage increased from 100 to 900 acres. Relative variability (coefficient of variation) for the smaller acreages was about twice that of the larger. This suggests that increasing the size of operation is a strategy to reduce business risk. Bostwick also found that the average yield per acre increased about 2-4 bushels an acre, as the wheat acreage increased from 100 to 600-800 acres and then variability decreased. A tentative explanation was that management improves through that size range and then reaches an optimum.

Perhaps Bostwick's most interesting finding was the relationship between wheat yields in successive years (5). Such a relationship seems reasonable, since rainfall one year may influence (through carryover soil moisture) the yield of the next year. To this question, Bostwick applied the Markov chain process, a statistical test for the significance of changes in probabilities the following year. Farms were sorted into five wheat-yield groups for one year and the distribution of yields noted the following year. The study included 612 yield observations, many used twice--once as year "one" and again as year "two." His results indicate that if this year's yield was less than 4 bushels an acre the probability of getting another low yield next year was 0.135 (about 1 in 7), whereas the longrun probability of such a yield is only 0.043 (about 1 in 23). Similarly, if this year's yield is 20 bushels or more, the probability of a like yield next year is 0.483 (about 1 in 2), whereas the longrun probability for such a yield is 0.282 (about 5 in 14). These results conclusively showed that in Montana, wheat yields of successive years are related. The best strategy for a farmer is to expect next year to be like this year.

Enterprise Combinations

To achieve income stability over time, farmers can combine enterprises whose incomes are affected differently by the same weather and economic factors. Hence, the factors that cause a loss in one enterprise may create a gain in another enterprise--the same year. Then a combination of the high and low net income enterprises in any one year would enhance stability. This relationship between enterprises can be measured by the coefficient of correlation, which tells the degree to which the enterprises tend to move in the same direction over time. A strong positive correlation indicates they move up and down in unison. A strong negative correlation would indicate they moved opposite each other and would enhance stability. Once the more stable combinations have been selected by tests of correlation, then the best proportion of each can be determined by computing coefficients of variation. Also, the proportionate combinations can be compared for average level of income.

North Dakota

For 1931-59, Schaffner studied the correlation among seven enterprises under dryland farming, among five enterprises under irrigation farming, and between the crop enterprises in dryland and irrigated farming (23). He based his correlations on the returns per $100 of all costs, as being of most interest to the farmer.

Schaffner found high positive correlations for most combinations of livestock, apparently because price variations were similar for each kind of livestock. Hence the strategy of combining livestock enterprises would not aid in stabilizing returns per $100 of all costs. For grain, he also found high positive correlations for dryland, irrigated, and dryland and irrigated combinations. The same basic economic and weather factors apparently

acted similarly on all grain crops. This strongly suggests that grain combinations likewise are not good strategy for stabilizing returns per $100 of all costs.

Schaffner found smaller positive and some negative correlations between the livestock enterprises and the grain enterprises (whether dry or irrigated). Hence these combinations would more likely lead to stability of income.

For the same period, 1931-59, Schaffner studied the effect on year-to-year variability of combining two enterprises in various proportions. The enterprises he considered, ranked in descending order of variability, were:

	Gross returns per $100 invested	Standard deviation	Coefficient of variation (percent)
Dryland barley	$173.82	$110.33	63.5
Dryland wheat	230.63	115.79	50.2
Irrigated barley	156.07	76.99	49.3
Irrigated alfalfa	333.58	103.75	31.1
Irrigated corn silage	218.40	56.56	25.9
Full-fed calf	114.98	23.70	21.0
Beef cow-calf fed	119.43	21.17	17.7
Feeder lambs	119.73	14.46	12.1

In general, the crop enterprises had higher average returns per $100 of inputs, and also greater variability than livestock enterprises. From the standpoint of both high returns and low variability, irrigated corn silage appears to be a desirable enterprise.

When enterprises from the above list were combined, two at a time, in various proportions, the proportions shown below in parentheses were found to have the least variability.

Enterprise combination	Gross returns per $100 input	Coefficient of variation
Irrigated corn silage (90%)--dry barley (10%)	$213.94	24.9
Irrigated alfalfa (60%)--dry wheat (40%)	292.40	24.4
Irrigated corn silage (80%)--dry wheat (20%)	220.85	23.7
Irrigated barley (20%)--full-fed calf (80%)	123.20	14.8
Dry barley (10%)--feeder lambs (90%)	125.14	11.6
Irrigated corn silage (30%)--beef cow-calf fed (70%)	149.12	9.9

In each instance the variability of the paired combination is less than the variability of either of the two enterprises alone. Substituting dryland wheat for 20 percent of the irrigated corn silage increases the returns from $218.40 to $220.85 per $100 of all costs, and decreases the coefficient of variability from 25.9 to 23.7 percent.

When Schaffner combined three enterprises by shifting some resource inputs from irrigated corn silage to equal proportions of dryland wheat and deferred-fed calves, he found the least variable combination to be 60-percent silage and 40-percent wheat-calves. That combination returned $200.86 per $100 input, with a C.V. of 19.9 percent.

Nebraska

Finley also studied the effect on income variability of combining two crops in different proportions (11). His study included combinations of corn-grain sorghum, corn-soybeans, and wheat-oats in 41 eastern Nebraska counties during 1943-58. Corn, soybeans, and wheat are high-return crops with high absolute variability (though moderate relative variability). Grain sorghum and oats are low-return crops with lower absolute variability, though average relative variability. Although both absolute and relative variability were measured, only the relative is reported here.

The combination of corn and grain sorghum having the least relative variability (coefficient of variation) in 23 counties (out of 41) was 50 percent of each crop. In 17 other counties, the least variability was with 75-percent corn, 25-percent grain sorghum. The combination of corn and soybeans having the least relative variability was 50 percent of each crop in 5 of 14 counties. In 7 counties, 100-percent corn gave the least relative variability. The combination of wheat and oats having the least relative variability was 25-percent wheat and 75-percent oats in 27 out of 28 counties, but the average gross income was much lower than with all wheat.

In Kimball County (western Nebraska), the combination of wheat and corn having the lowest variability was 30-percent wheat and 70-percent corn. No combination of wheat-barley, wheat-oats, or wheat-grain sorghum had a lower income variability than barley, oats, or grain sorghum grown alone.

Evaluating his results on variability of crop combinations, Finley concluded that the lowest year-to-year variability was achieved in general only at a sacrifice in average gross income. A farmer would have to decide how much average income he could sacrifice in order to reduce his year-to-year variability. If profit margins are generally wide, there may be less actual risk of financial failure in staying with the higher return crops, because risk is always a complex matter.

Oklahoma

Greve found that wheat yields in 1942-57 were not related to grain-sorghum yields nor to livestock production from native range (12). In a favorable year for wheat, the probabilities are about equal for a good, bad, or indifferent year for grain sorghum, steer, and cow-calf production. Winter wheat, of course, has a different growing season than sorghum and native range. However, gross returns and net returns per acre of grain sorghum are not significantly correlated with returns from livestock enterprises per acre of native range. Production, prices, and returns--each correlate closely for steer and cow-calf enterprises. Greve did not test the combinations of enterprises having the least joint variability.

Texas

Johnson and Tefertiller found a correlation coefficient of 0.48 between dryland cotton and grain sorghum yields at the Lubbock Station, using 30 years' data (16). Though not a high coefficient, this result led them to test the variability of various combinations of the two crops. They found annual net income varied least when 44 percent of the cropland was in cotton and 56 percent in grain sorghum. However, the variability was not much higher and average net income was greatly increased when the cotton acreage was increased to 60 percent and grain sorghum lowered to 40 percent.

Enterprise combination was also studied for cotton and grain sorghum when cotton is under acreage allotments. Cotton produced about the same area yield and the same net cash return when grown in a skip-row system of two rows of cotton and two idle, or two rows of cotton and one idle, as it produced when grown in solid 40-inch rows.

	Cotton (30 cents/lb.)			Grain sorghum ($1.60/cwt.)
	40-inch rows	2x1 rows	2x2 rows	40-inch rows
Gross receipts	$93.36	$91.38	$79.92	$24.00
Cash expenses	28.02	25.55	22.10	6.05
Net return	$65.34	$65.83	$57.82	$17.95

When the enterprises were combined on a farm of 300 acres of cropland with a 105-acre cotton allotment, the returns from enterprise combinations were as follows:

	40-inch rows	2x1 rows	2x2 rows
Acres "occupied" by cotton	105	157	210
Acres in grain sorghum	195	143	90
Returns above cash expenses	$10,361	$12,902	$13,758

Flexible Livestock Systems

Livestock systems are flexible if they can readily expand or contract with changing feed supplies or other conditions. The concept applies mainly to cattle- and sheep-raising on range or pasture, and mainly with breeding herds or flocks. In the case of stocker-steer operations, flexibility is attained merely by adjusting the number of animals bought to put on pasture for the season.

In cattle raising, on the other hand, flexibility is achieved by adjusting the cow herd size to something less than normal pasture-carrying capacity. Then, in above-average grass years, enough calves are carried over and grazed as yearlings to use the additional grass. A modification of this is to adjust the cow herd itself by culling heavily during periods (years) of short grazing, and lightly in periods of lush grazing. Still another way is to combine a stocker-steer enterprise with cow herd operations.

Two cooperative studies between ERS and experiment stations (but not formally designated as contributing projects to the GP-2 regional project) are reported here.

Economic Research Service (Kansas)

Nauheim and his associates interviewed 173 dryland farmers and ranchers in western Kansas in June 1957 to see how they had adjusted their livestock (cattle) operations to a 5-year drought which had just broken. Data were obtained for 1952-57 for a stratified sample including seven systems of cow herd operations, five systems of purchased stocker-steer operations, and mixed systems. 4/ Operators were asked why they changed operations during the drought and what were the relative merits of different operating systems.

Nauheim found that along with greatly reducing cattle numbers during a drought, many operators had shifted from a breeding cow herd or from a mixed operation to purchasing stocker steers for seasonal grazing. The shifts can be summarized as follows:

System	Number of operators 1952	Number of operators 1957	Shifts Number	Shifts To--
Cow herd	114	91	22	Purchased stocker steers
			3	Mixed operation
Purchased stocker steers	47	75	1	Cow herd
Mixed system	12	7	7	Purchased stocker steers
			1	Cow herd
Total	173	173		

In total, 29 operators shifted entirely to purchased stocker steers and 3 others to a partly purchased type of operation. Operators said the main reason for the change was lack of feed (75 percent). Other reasons were high price of purchased feed (9 percent) and shortage of land or water, etc. (6 percent). Capital, credit, and labor were not mentioned or were given very minor consideration.

The operators were also asked why they preferred specified systems of cattle operation. The reasons given for preferring cow herds (in order of importance) were:

Less risk of price and production loss,
No problem of buying cattle (as with steers),
Use pasture and roughage,
More experience in handling cows,
Source of ready cash and income (assets to be sold),
Collateral for loans,
Personal preference,
More profitable than other systems.

4/ Data for each year included acres in farm, acres in pasture, number of animal units, composition by age and sex, number and weight of cattle bought and sold, feed purchases, and other expenses.

Those preferring purchased-steer systems did so because they were considered more flexible, more profitable, required less regular pasture, and required labor chiefly in the less busy winter months.

All operators having purchased-steer systems considered them more flexible than the cow herd system. Sixty percent of those having cow herds considered them more flexible than purchased-steer systems; but 40 percent agreed with the first group.

As expected, most operators (169 of the 173) had to adjust feed supplies during the drought. In order of importance, they bought additional feed, increased the acreage of feed crops or temporary pasture, used up reserves of feed, grew feed crops on summerfallow land, sold less feed off the farm, rented additional pasture, irrigated some pasture, and rented the aftermath of harvested crops. Cow herd operators and purchased-steer operators adjusted feed supplies in the same ways, but the former used more variety.

Nauheim examined the flexibility of cow-calf, cow-yearling, and cow-2-year-old systems each having 125 animal units (a.u. equal a mature breeding cow), constituted as shown below.

	Cow-calf system	Cow-yearling system	Cow-2-year-old system
		Head	
Number of head of--			
Cows	93	67	49
Calves (8 months)	79	57	41
Yearlings (20 months)	10	56	40
2-year-olds (30 months)	---	---	40
		Percent	
Percentage of animal units:			
Cows	75	54	39
Calves (8 months)	19	14	10
Yearlings (20 months)	6	32	22
2-year-olds (30 months)	---	---	29
	100	100	100
Change in type of operation:			
Contraction in a.u. possible without reducing cow herd	-25	-46	-61
Expansion in a.u. possible (without increasing cow herd) to--			
Cow-yearling system	+40	N.A.	N.A.
Cow-2-year-olds system	+92	+40	N.A.

In a drought, the number of animal units (hence feed requirements) can be reduced least (-25 percent) in the cow-calf system, and most (-61 percent) in the cow-2-year-old system without reducing the basic cow herd. Conversely, in a period of above-average rainfall and forage, the number of animal units can be expanded most (+92 percent) in the cow-calf system, but not at all in the cow-2-year-old system without expanding the cow herd. Hence the cow-calf system is the least flexible in a drought, but the most flexible when there is abundant grass. The cow-yearling system has two-way flexibility, allowing either a 46-percent reduction or a 40-percent expansion without a change in the cow herd. Using 1947-56 average prices, Nauheim estimated the long-run average gross returns from the 3 systems (each with 125 a.u.): cow-calf $10,420, cow-yearling $9,967, and cow-2-year-old $9,442.

Such are the basic flexibilities in cattle-raising. If even more drastic adjustment is needed during a drought, the cow herd can be culled even more severely or sold in its entirety. Possibly, the replacement calves and heifers on hand can be kept to facilitate restocking when the drought has ended.

Nauheim observed that measures to achieve flexibility usually entail some cost to the rancher, so flexibility combined with a system of feed reserves may be the better management strategy.

Economic Research Service (New Mexico)

Boykin of ERS and Gray of the New Mexico station studied area and individual ranch adjustments to drought from 1948 to 1959 in the Plains of eastern New Mexico (8). They found that most ranchers tried to maintain cattle inventories during the drought by purchasing extra feed and by leasing additional rangeland. Most ranchers expected the drought to end soon and feared they would be unable to replace their herds with quality animals after the drought. As the drought persisted, more and more ranchers reduced their cattle inventories by more selective culling of breeding stock and by holding fewer calves over for sale as yearlings. With this type of inventory management, ranch turnoff of cattle actually increased during the drought, but inventories were smaller at the end. Although turnoff increased, the net ranch income decreased during the drought, due to increased costs (mainly for feed purchased and land leased) and a decline in prices, partly caused by the volume of drought sales but mainly because of the U.S. trend in cattle prices.

Increased costs for feed purchased and range leased more than offset reduced expenditures for hired labor, repairs, maintenance, and deferred replacement of capital items. As it was, many ranchers would have benefited had they reduced their herd inventories earlier when cattle prices were still high, or had they regularly kept a smaller breeding herd and regularly carried over more calves for sale as yearlings whenever the forage warranted. Not many ranchers realized how rapidly a depleted herd could be restored after a drought, merely starting with heifer calves.

Because drought affects feed purchases directly and range productivity indirectly, the problem of minimizing total costs and managing livestock inventories are important during droughts. Boykin concluded that the number of cows should be held at about the number suited to the most probable long-term average forage production in this year-round grazing area.

Feed Reserves

Farmers and ranchers in the Plains have been admonished about many things, but perhaps on none more persistently than that they should "carry over feed reserves." Such advice seems unassailable when drought comes and there is no feed for the cattle. However, the economics of feed reserves are subtle. The subtlety shows up in considering the most economic way to dispose of hay reserves when the drought year appears. Is it more economic at such a time to use the reserves (which are then high in price) for feed or to sell them at a profit? A further economic fact is associated. The cattle to be fed the reserves may be depressed in market price due to the shortage of feed and expanded cattle marketings. Thus the rancher may find himself feeding high-priced hay to low-priced cattle. This question has not been explored under the regional project, GP-2. The more limited question of using hay reserves to stabilize cattle-raising operations was studied by Nebraska. This question is the obverse of flexible versus stabilized livestock systems.

Nebraska

Using hay reserves as a stabilizing strategy was studied on a model of a 480-acre farm in Sherman County for 1920-57, which included the prolonged droughts of both the 1930's and the 1950's(1). One system assumed the cow herd was held constant at 35 head--about the average carrying capacity of the range over time. Surplus forage from good years was stored as hay reserves for use in poor grass years. In the other system, the cow herd was adjusted to the actual carrying capacity, year-by-year, on the basis of a 3-year moving average of forage production. Prices were held constant. In the system using hay reserves, gross income varied much less (C.V. 82 percent) than in the other system (C.V. 126 percent). However, gross income also averaged lower ($886 versus $1,108). Consequently there were only 3 fewer years (8 versus 11) in which the hay-reserve system experienced a net cash loss. Net income neither went as high ($2,057 versus $3,465) or as low ($-426 versus $-1,523) as with the other system. This is another instance in which stability is "bought" with some sacrifice in income.

Financial Reserves

Reserves are assets set aside for use as future income when needed. A business firm may choose to operate without reserves, but it cannot avoid the conversion of assets to income whenever income is insufficient to meet current expenses or obligations because there is no other source of income. The conversion of assets to income can take three forms:

(1) Used as a direct input (as stored food, feed, seed, repair parts, tractor fuel, etc.),

(2) Sold for cash (as stored grain, livestock inventories),

(3) Used as collateral for a money loan.

Each of these forms of conversion reduces the assets or net worth of the business firm--even under (3). In (3) part of the ownership rights are "sold" to a banker or other moneylender. Reserves represent a prior commitment or setting aside of a portion of the assets.

Keeping reserves usually represents some cost to the firm because the assets are idle or used less productively. They may represent an opportunity foregone. Still, a farmer may choose to keep physical reserves of feed or seed if he thinks they might be unavailable or high in price in time of drought. Physical reserves, like other assets, may be used as collateral for money loans for funds to operate the firm. In this instance, the "cost" of the reserve is the loan rate of interest. Physical reserves entail problems of inventory management. Reserves in whatever form need not be liquidated in time of need but can be used as collateral for bank loans.

Because reserves can be converted from one form to another, they can be studied as one lump sum as Hjort did in his study, described below.

Economic Research Service (Montana)

Hjort studied the total value of reserves needed by dryland wheat farmers in Montana (14). In a given year, the need would be the amount by which income failed to cover variable farm expenses (excluding depreciation and capital replacement) plus direct household expenses. For example, on a 1,640-acre farm--one considered adequate for dryland wheat farming--the reserve for a zero-yield year would be about $6,700. The maximum reserve needed at any one time would be the amount by which accumulated annual incomes failed to average that amount over a period of poor crop years.

Hjort constructed year-to-year income budgets for the farm using 37 different yield series in the north-central (winter wheat) area and 30 in the northeast (spring wheat) area. Each yield series was from an actual farm, varying in length from 14 to 24 years, and ending in 1956. Average wheat yields varied widely among the series, from 6.2 to 17.5 bushels an acre in the northeast, and from 14.1 to 29.3 bushels in the north-central. Coefficients of variation ranged from 36.0 to 64.8 percent in the northeast; from 30.6 to 60.4 percent in the north-central.

Likewise, the maximum reserves needed by the farm at any one time varied from $472 to $35,550 among the 30 yield series in the northeast, and from no reserves to $41,061 among the 37 series in the north-central. Grouping the series into high, middle, and low third for each area the data summarize as shown below.

Rank of yield series	Number of series	Years	Average wheat yield	Standard deviation	Coefficient of variation	Maximum needed reserves
	No.	No.	Bu.	Bu.	Pct.	Dol.
			Northeast (spring wheat)			
High	10	17.5	15.6	6.64	42.7	4,370
Middle	10	17.1	13.3	6.36	47.9	5,510
Low	10	18.9	10.4	5.67	53.9	11,950
			North-central (winter wheat)			
High	12	18.8	20.5	8.22	40.6	4,850
Middle	13	18.4	15.8	7.26	45.8	7,960
Low	12	17.8	11.5	5.45	47.5	13,860

Spatial Diversification

This strategy was studied only in Montana (15). In the subhumid Plains seasonal rainshowers, hailstorms, and crop yields are often spotted geographically. A typical rainshower is up to 10 miles wide, travels from west to east, and may contain hail in the center half-mile. Such a storm may exert its full impact on a farm composed of contiguous fields, or it may bypass the farm. Not so with a farm composed of dispersed, noncontiguous fields. Here, some but not all fields experience a timely shower, a destructive hail, or a sapping drought. Hence, total production of the dispersed farm is likely to vary less from year-to-year, though its long-run average will equal that of the nondispersed farm.

Jensen and his associates tested this hypothesis using wheat yield data from lease records of the State-owned land for 1937-56 in northeast Montana. He identified typical nondispersed dryland wheat farms and then synthesized dispersed farms of the same size, but with field segments dispersed 0-1 mile, 1-4 miles, 7-10 miles, 10-15 miles. Then he computed the annual total wheat production for each farm and computed the year-to-year variance. The resulting reduction in variance (yield variability) associated with unit dispersion, by size of farm is summarized as follows:

Acres in wheat	With units dispersed	Variance (variability) reduced by--
100-200	10-15 miles	One-third
200-600	4-7 miles	One-fourth
600-1,000	4-7 miles	Two-thirds
1,000 +		(Variability unaffected)

Unit dispersion reduced year-to-year variability of total wheat production on farms having less than 1,000 acres of wheat, but not on larger farms.

On farms with 100 to 200 acres of wheat, variability was reduced only when the field units were dispersed 10 to 15 miles, in which case the variance was reduced about one-third.

On farms with 200 to 600 acres of wheat, variability was reduced when the field units were dispersed at least 4-7 miles, in which the variance was reduced about one-fourth. Variance was not further reduced by greater dispersion.

On farms with 600 to 1,000 acres of wheat, a dispersion of 1-4 miles reduced variance about one-half and dispersion of 4-7 miles reduced it about two-thirds. Dispersion beyond 7 miles did not reduce variance any futher.

Unit dispersion had a discontinuous, steplike effect on yield variability, which had not been anticipated by the researchers. Yet the variances are statistically significant, so we must conclude that dispersion does affect yield variability in certain specified circumstances.

Aside from stabilizing farm income, greater stability of a farm's production can have these ancillary benefits:

(1) Improve the prediction of crop yields, income, credit needs, and loan repayment capacity of the farm business,

(2) Reduce the size of needed reserves (cash, feed, etc.),

(3) Reduce crop-insurance premiums, and possibly reduce the need for such insurance.

Crop Insurance as a Strategy

Crop insurance has long been advocated in the Plains as a means of protecting farm income against natural hazards such as drought, hail, insect damage, and so on. Other means of protection are storing reserves, putting away funds, or use of short-term credit. Crop-hail insurance has been available for many decades either from commercial companies or from State-sponsored agencies. Since 1938, Federal crop insurance has been available in some States and counties.

Insurance shifts all or part of the uncertainty of natural hazards to the insuring agency. Farmers who buy no insurance carry the burden of uncertainty themselves.

Whether drought in the Plains is an appropriate risk for insurance may be questioned. Traditionally, insurance has been used to protect the user against an unusual event that would be disastrous to the insured. Fire and accidental death are in this category. In much of the Plains, drought is not unusual (it may occur 1 year out of 3 or 4) and its consequences, though serious, are not disastrous. What the farmer loses is his investment in production expenses--not a bumper crop or an average crop. There may be other production hazards in the same category as drought.

Crop-hail insurance is a different matter. Hail damage is neither as general in its effect nor as "usual" (for the individual farmer) as drought. The real risk of hail damage occurs after a good crop is in sight, say within 30 days or less of harvest, when the crop is about "made." The prospective good crop represents a handsome income if it can be harvested without damage, but a "loss" far exceeding the investment costs if it is hailed out. Many farmers recognize this, and buy hail insurance when crop prospects are good.

Drought is a more unusual hazard in the more humid areas, but even there it seldom strikes after a good crop is in sight.

The Economic Research Service, in cooperation with the Montana Agricultural Experiment Station, studied the economics of insurance in Montana. After that study was completed, a Great Plains regional research project (GP-8) was established for further study of crop insurance.

Economic Research Service (Montana)

Rodewald and his associates interviewed a probability sample of dryland wheat farmers, to learn their use of and attitudes toward all-risk insurance and crop-hail insurance (20). The all-risk insurance is available from the Federal Crop Insurance Corporation. Coverage is limited to the standard production costs before harvest, not to exceed 75 percent of the value of the average yield of the insured farm. Such insurance contracts predate the production season. Crop-hail insurance is offered

by commercial companies with coverage up to the full value of the expected crop, at any time before harvest, at appropriate premiums. Premiums of each kind of insurance are based on actuarial tables of probable occurrence.

Rodewald found that many of the farmers interviewed carry both all-risk (FCIC) insurance and hail insurance. He concluded that the all-risk policy offered in 1959 did not meet the cash needs of dryland farmers in the northeast area. To meet these needs, the coverage would have to be increased from 7.9 to 9.5 bushels an acre. He also found that coverages based on production costs may not be adequate to cover family living expenses. Coverages established before wheat allotments were in effect may be inadequate to cover total farming costs now because a lower-return crop, such as barley, is grown on the nonallotment acres. That problem is lessened whenever barley insurance is available. He suggested an expansion of barley insurance and the extension of coverage to include minimum family-living expenses, with appropriate increase in premium rates. He found that crop-hail insurance is especially appropriate when crop prospects are good, but may not be justified when very low yields are expected.

Renting Land

Landownership has been the accepted goal of U.S. farmers since the time of Thomas Jefferson: Ownership would provide security and guarantee to the farmer all his earned income. This concept seemed especially valid when farms were small and largely self-sufficient. As farms have become larger and more commercialized, and have required more capital investment, the alternative of renting land has gained favor. ERS studied this question in a project not specifically designated as a contributing project.

Economic Research Service (Montana)

Rodewald and his colleagues interviewed 200 dryland farmers in 1960 to learn how they had entered farming and how they had progressed (21). Those entering before 1940 had purchased much of their land. Some had homesteaded or rented it. Entrants between 1940 and 1950 purchased less of their land and rented more of it. For entrants between 1950 and 1960, renting became almost the only source of land. Land renting increased, even though the average beginner's assets had increased from about $2, 200 before 1940 to $12, 000 in 1950-60. The capital investment required to buy a farm had increased even faster. Also, the average starting capital needed for operating expenses had increased from about $1, 000 to $7, 000.

Rodewald found that the total investment in a grain farm had become so large (about $129, 000 for a 1, 156-acre crop farm) that beginning operators, with equities as low as 20 percent of the value of land and buildings and one-third of the machinery, could not hope to meet the amortization payments toward full ownership, after meeting operating and living expenses and a reserve for depreciation. They could not accumulate capital out of earnings at a sufficient rate. Consequently, the only way that a person with low equity could start farming would be as a tenant. The full-owner position offered little chance of surplus capital accumulation.

Perhaps these findings were to be expected, because few middle-income wage earners in our economy can accumulate lifetime estates as large as that represented

by a medium-size wheat farm. Few businessmen today can become the debt-free sole owners of a business enterprise. Both farmers and other businessmen now can manage far more capital than they can own.

Renting land permits the farm operator to acquire and operate an efficient-size business and earn the management returns it affords without contributing all the capital.

Partial Irrigation of a Dryland Farm

Irrigation has seemed an obvious solution to improved income and greater stability in the Plains, because irrigated crops yield more and have less year-to-year variation than dryland crops. The chief problem has been a dependable and economic source of water in a region where streams are often intermittent and ground water is hundreds of feet below the land surface. Water has become more available through public storage projects, and through more efficient pumps for private wells. Many studies have shown that irrigation farming is feasible and that it improves farm income. A further question is whether the returns to a farmer from investing additional capital in irrigation are greater than from using more fertilizer on dryland crops, feeding livestock, and other land uses. This question was studied in one of the contributing projects to GP-2.

North Dakota

In one phase of his project, Schaffner developed optimum plans for a 640-acre farm model with 480 acres of cropland, of which 160 acres could be irrigated (22). Using linear programming, he considered 22 crop rotations (with and without fertilizer) for dryland, 12 rotations (fertilized) for irrigation, and 8 different livestock enterprises. Resource restrictions in addition to land included: wheat allotment, 90 acres; irrigable land, 160 acres; capital (excluding land) varied from $4, 000 to $33, 000; and farmgrown forages. In some plans, feed grains were limited to those that were farm-grown; in others, feed grains could be purchased.

Schaffner determined that partial irrigation did not contribute significantly to faster capital accumulation than the same investment in dryland production. The marginal rate of return to capital was higher in dryland farming. He concluded that crops having higher returns per acre and higher risks would accumulate capital (net proceeds) faster over time than would low-return, low-risk crops.

Schaffner found that the most profitable managerial strategies for additional capital investment could be summarized as follows.

1. When operating capital is limited, the farm should be operated as a dryland unit, with all wheat grown on summer fallow.

2. Funds should be invested in fertilizer before irrigation or livestock.

3. If forage can be sold for cash, investment pays better in irrigation than in livestock.

4. Feeding purchased cattle is more profitable than other livestock enterprises for any funds above those needed for crop production, fertilization, and irrigation.

5. When home-grown feeds limit livestock production, it is more profitable to grow all forage and buy the feed grains.

6. The sequence for investing limited capital funds is dryland crops, then fertilization of dryland crops, irrigation, and buying feeder cattle.

Production Technologies

If we had more information about the interaction between production practices and weather on crop yields, perhaps we could employ the practices more wisely and economically. This interaction was studied specifically under one of the contributing projects.

Kansas

Wearden and Orazem studied the effects of: Depth of soil moisture at seeding time, rainfall during the growing season, and nitrogen and phosphorus fertilization on the yield of grain sorghum grown on sandy lands in southwestern Kansas (37). Their data were from farmers who cooperated with the experiment station in 1951-56. It included 14 fertilizer treatments and 8 moisture levels, with 4 to 5 replications per treatment--382 yield observations in all.

Soil moisture at planting time was more highly correlated with yield than was seasonal rainfall. The latter had more effect on yields when soil moisture was low at planting time. Yield response to phosphorus was negligible under any and all moisture conditions. First increments of nitrogen affected yield more than later increments. Predictive equations indicated a yield of 6.6 bushels per acre when soil was moist to 24 inches at planting, seasonal rainfall was 2 inches and no nitrogen applied. A yield of 47.8 bushels was associated with soil moist to 60 inches, seasonal rainfall 8 inches, and 90 pounds of nitrogen applied. Sorghum yields fell between these extremes when the soil was moist to 36 inches or 48 inches at planting, when the seasonal rainfall varied from 2 to 8 inches, and the nitrogen applied varied from 0 to 90 pounds per acre.

The Paradigm

Perhaps the most intriguing concept or technique introduced to GP-2 was Don Bostwick's management paradigm--a framework for studying the management process. The need for it was emphasized by Glenn Johnson in his summary of the Strategies Workshop 5/ and by the intense interest shown by GP-2 members. When fully developed, the pardigm promises to fill a need thus far unsatisfied in farm-management research.

GP-2 has persisted in working--as evidenced in this report--with segments of overall management strategy, i.e., with individual stratagems such as reserves, credit, crop insurance, flexibility, technologies, and so on. This attack is ultimately futile because all the stratagems must be brought to bear on the overall management problem.

5/ Held by the GP-2 Technical Committee, May 5-7, 1959, at Lincoln, Nebr.

Bostwick's paradigm is a theoretical model--a general model, not intended, as in the usual sense, to represent a specific farming situation. It is a structure designed to accommodate different sets of farm resources, levels of beginning equities, production processes and activities, physical and financial reserves, crop insurance, managerial capacities, production credit, rental arrangements, off-farm earnings, and other management stratagems. Inputs to the process could include different year-series of weather, yields, and prices.

In describing his paradigm, Bostwick said, "Think of a sort of electronic circuit composed of a network of wires and nodes. Think of the nodes as cells where values are stored, and of the wires as devices that both transfer and change values between nodes." Bostwick's paradigm, shown schematically in figure 2, shows the complex relationships and interrelationships among the elements of an integrated farm financial management strategy. Although time ran out in GP-2, we believe that we can solve the overall problems of theoretical management strategy.

PART II. THE CONTRIBUTING PROJECTS

In this section, the contributing projects of each agency are discussed. First, the question or proposition that was being studied is described, then what the objectives were, what work was planned, and finally (and very briefly), what was learned from the study. The discussions are in the author's words, not in those of the project statements or the final published reports. For brevity, the name of a State is used to mean the agricultural economics staff of an agricultural experiment station in that State.

Six agricultural experiment stations and the Economic Research Service had projects contributing to GP-2. Each station and ERS contributed papers to a workshop on managerial strategies at Lincoln, Nebr. (May 1959), and to a livestock ranching symposium at Bozeman, Mont. (May 1962).

Montana

Montana had a project on spatial diversification of farms. In addition, it cooperated with ERS on studies of crop-yield variability, the attitudes of farmers and lenders toward the use of credit in farming, the reserves needed by wheat farmers, and the economics of crop insurance.

Project on Spatial Diversification

Proposition--How can spatial diversification be used to stabilize crop production and income; how will it affect farming costs?

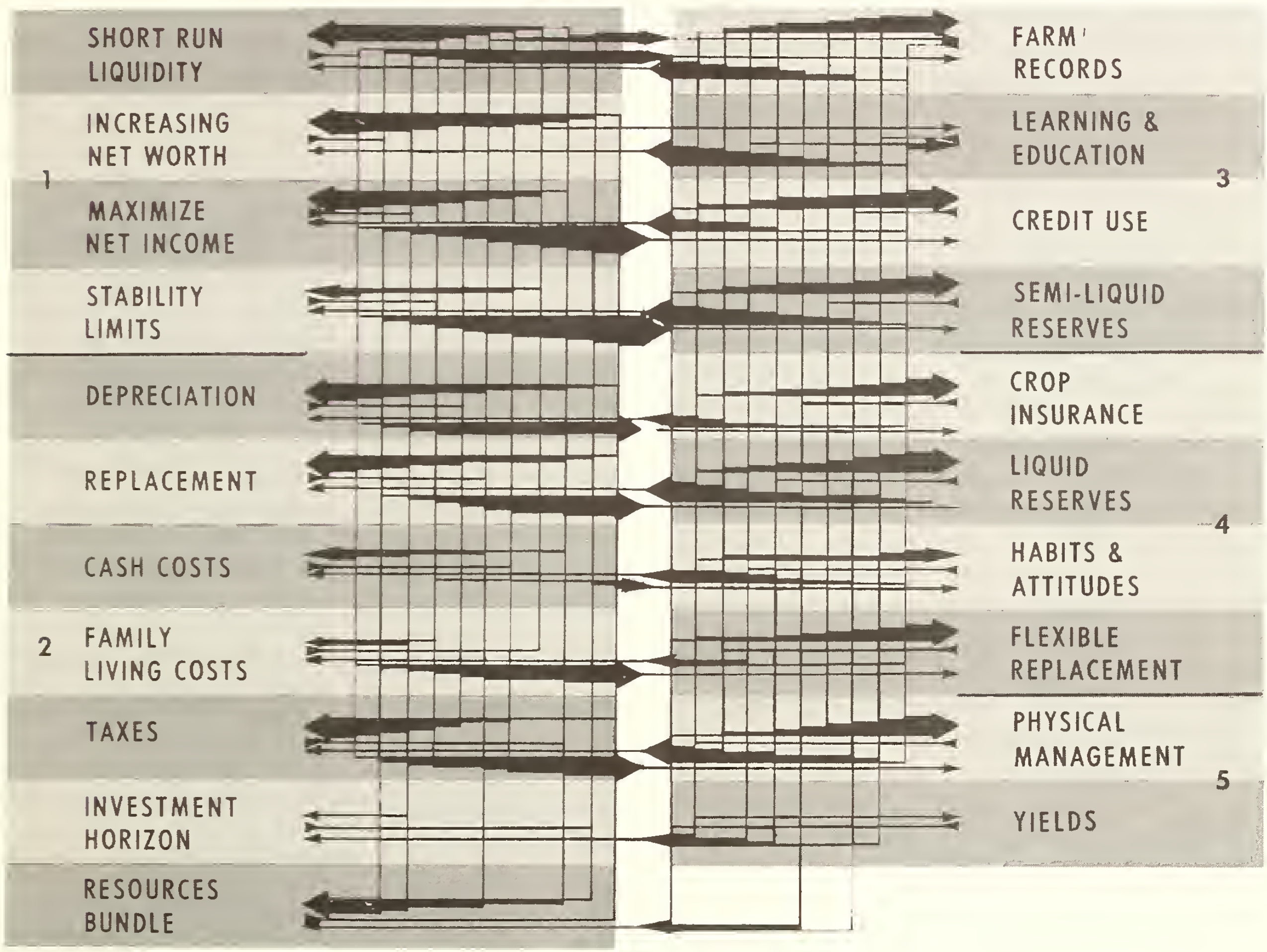
Objectives--To determine the effect of spatial diversification on:

(1) Variability of crop production and income of a farm,

(2) Costs of operating farms,

(3) Farm business survival.

SCHEMATIC PLANNING SYSTEM
Focus on Financial Management Strategy



PROCESSES

1. Goal Seeking & Gratification
2. Calculation & Control
3. Integration
4. Defense
5. Nodes Exogenous to this System

UNITED STATES DEPARTMENT OF AGRICULTURE NEG. ERS 4640-66(7) ECONOMIC RESEARCH SERVICE

Figure 2

Work Planned

In the northeastern area, Montana planned to identify typical, nondispersed dryland wheat farms; synthesize dispersed wheat farms of the same size with field segments dispersed 0-1 mile, 1-4 miles, 4-7 miles, 7-10 miles, 10-15 miles, and 15+ miles; compute for each farm the annual wheat production and the coefficient of variation; and evaluate the influence of dispersion (aside from other adjustments) on the "staying power" of dryland wheat farms.

Annual yields for the dispersed segments were from lease records of Montana State-owned land.

Results

North-south spatial dispersion did reduce the year-to-year variation in the total crop production (average yields) of dryland farms having less than 1,000 acres of wheat. On farms with 600 to 1,000 acres of wheat, dispersion of 1 to 4 miles reduced yield variability a half, and dispersion of 4 to 7 miles reduced it about two-thirds. On farms with 200 to 600 acres of wheat, dispersion of 4 to 7 miles reduced yield variability about one-fourth. On these two groups of farms (200 to 1,000 acres of wheat), unit dispersion exceeding 7 miles did not appreciably reduce the year-to-year variability of total farm production. On farms with 100 to 200 acres of wheat, unit dispersion of 1-4 miles reduced variability nearly one-third; any greater dispersion had little effect on variability. Thus the real payoff on reduced variability was with the small farms (100-200 acres) dispersed 1 to 4 miles and with the medium-size farms (200 to 1,000 acres) dispersed 4 to 7 miles.

Unit dispersion did not reduce variability on large farms with more than 1,000 acres of wheat. Apparently, these farms achieved stabilizing effects on farm production without spatial diversification.

The variances of year-to-year total farm production in the northeast Montana spring wheat area for 1937-56 are summarized below.

Acres in wheat	Variance with fields dispersed--				
	0-1 mile	1-4 miles	4-7 miles	7-10 miles	10-15 miles
			Bushels		
100 to 200	40.4	28.7	30.3	30.7	26.9
200 to 600	40.7	46.5	30.1	31.8	31.0
600 to 1,000	90.9	46.4	29.6	30.1	29.2
1,000 and over	18.8	31.1	30.0	28.0	21.9

Aside from stabilizing farm income, greater stability of production can have these benefits:

(1) Improve prediction of crop yields, income, credit needs, and loan-repayment capacity of the farm business,

(2) Reduce the size of needed reserves (cash, feed, etc.),

(3) Reduce crop insurance premiums, and possibly reduce the need for such insurance.

Further Work Planned at Time of Report

Montana does not plan to analyze east-west dispersion, because preliminary work indicated that it would be ineffective. Plans are to budget a study of three size groups (under 1,000 acres of wheat) of dispersed farms to determine typical costs of dispersed farm operations. For comparison, data are available on farm operating costs of nondispersed farms.

North Dakota

Project on Irrigation

Proposition--How will irrigation, when interspersed among dryland farming, affect the optimum use of resources, net farm profits, capital requirements, income stability, and capital accumulation? The emphasis is on stabilizing rather than increasing income.

Objectives--For representative dryland farms in the Plains area of North Dakota, determine:

(1) Variation in year-to-year income,

(2) Yield and income variability of irrigated and dryland crop and livestock enterprises,

(3) What combinations of enterprises are less variable,

(4) Whether the risks and uncertainties of irrigation have a greater or lesser impact than dryland farming variations have on farm income.

Work Planned

North Dakota planned to compute the year-to-year variability of dryland crop yields in a north-central county for 1931-59; do the same for irrigated crops on the Lower Yellowstone Irrigation Project; compute the year-to-year variability of crop and livestock prices around the trend; compute the variability of gross income and of net income of each crop and livestock enterprise; do the same for combinations of enterprises; budget a study of a 640-acre model farm in north-central North Dakota, with up to 160 acres of the farm irrigated; and compare the income variability of these farms with that of a wholly dryland farm.

Results

The research results are reported under two phases.

In one phase, year-to-year variability of dryland crops, irrigated crops, and livestock were studied in north-central North Dakota for 1931-59 (23). The variance, standard deviation, and coefficient of variation were computed for yield per acre (of crops), gross income, net income, and returns per $100 of all costs. Enterprises included combinations of seven dryland crops, five irrigated crops, and five livestock enterprises (beef-cattle, dairy, hogs, ewe-flock, and lamb-feeding).

Average dryland and irrigated crop yields per acre for 1931-59 are listed as follows:

	Dryland	Irrigated	Ratio of irrigated land to dryland
			Percent
Wheat	20.50 bu.	37.80 bu.	184
Oats	28.52 bu.	71.70 bu.	251
Barley	25.28 bu.	51.50 bu.	204
Flax	6.81 bu.	N.A.	N.A.
Corn silage	4.00 ton	12.30 ton	307
Alfalfa	1.97 ton	4.10 ton	208
Wild hay	.73 ton	N.A.	N.A.

The coefficients of variation of yields and incomes of selected crop and livestock enterprises were as follows:

	Yields	Gross income 1/	Net income 2/	Return per $100 of all costs
	Percent	Percent	Percent	Percent
Dryland crops				
Wheat	45	63	86	50
Barley	45	70	123	63
Flax	58	77	111	68
Corn silage	34	51	96	37
Alfalfa hay	31	51	69	28
Irrigated crops				
Wheat	25	55	74	35
Barley	24	61	120	49
Corn silage	22	47	62	26
Alfalfa	14	44	51	31
Livestock				
Beef cow-calf sold		56	188	16
Short-fed yearling		49	94	21
Dairy		45	64	10
Hogs		44	90	22
Sheep (ewe flock)		46	93	11

1/ Computed with actual prices.
2/ Gross income minus all variable and fixed costs including family labor and interest on capital investment.

Among dryland crops, yield variability was nearly a half larger for grain crops (wheat and barley) than for forage crops (corn silage and alfalfa hay). Irrigation reduced the year-to-year yield variability of all crops: that of grain crops about 40 percent, and of alfalfa about 50 percent. Irrigation did not eliminate all of the yield variability--only about half of it.

Incomes from crop enterprises varied more than the yields, because incomes were subject also to price variability. Variability in gross income was greater in the dryland crops than in irrigated crops, but the difference was less than in yields.

Variability in gross income was greater in grain crops than in forage crops but about the same for forage crops and livestock. In general, the variability of gross income was smaller than the variability of net income, but it was larger than the variability of return per $100 of all costs.

The second phase of the project concerned the economics of partial irrigation on a dryland farm (22). Data were from a survey of 64 farmers on the Lower Yellowstone Irrigation Project and from dryland farms. The object was to compare the returns from investment in irrigation with investment (1) in expanded dryland crop enterprises, (2) in added inputs to dryland crops, and (3) in livestock feeding enterprises. Optimum plans for a benchmark 640-acre farm with 480 acres of cropland, of which 160 acres could be irrigated were computed by linear programming. Sixty-four crop and livestock enterprises were considered--44 crop rotations for dryland, 12 for irrigation, and 8 for livestock. Resource restrictions included land, wheat allotment, irrigable acres, feed grains and hay, and operating capital. Programming results indicated:

1. When a farmer's operating capital is limited, he should operate his farm as a dryland unit, with all wheat on summer fallow.

2. He should invest funds for recommended fertilizer applications before going into irrigation or livestock.

3. If forage can be sold for cash, he should invest in irrigation before going into livestock.

4. Buying feeders to feed out is the most profitable livestock system for investing any funds over and above what is needed for crop production, fertilization, and irrigation.

5. When home-grown feeds limit livestock production, it is more profitable to grow forage and buy any further feed grains needed.

6. The sequence for investing limited capital is first to dryland crops, then fertilization of dryland crops, irrigation, and finally, buying feeder cattle or lambs.

The resulting crop and livestock organization, operating capital and spendable income (gross returns minus cash operating expenses and depreciation) are given as follows. Programming was based on crop rotations not shown here.

	Plan I	Plan II	Plan III	Plan IV	Plan V	Plan VI	Plan VII
	Acres						
Dryland							
Wheat	90	90	62.8	62.8	62.8	64.0	64.0
Fallow	90	60	40.0	40.0	40.0	---	---
Alfalfa	150	180	120.0	120.0	120.0	128.0	128.0
Corn silage	---	---	---	---	---	64.0	64.0
Barley	50	60	40.0	40.0	40.0	32.0	32.0
Oats	50	30	17.2	17.2	17.2	---	---
Flax	50	60	40.0	40.0	40.0	32.0	32.0
	480	480	320.0	320.0	320.0	320.0	320.0

--Continued

	Plan I	Plan II	Plan III	Plan IV	Plan V	Plan VI	Plan VII
				Acres			
Irrigated							
Wheat			26.7	26.7	26.7	26.7	26.7
Alfalfa			80.0	80.0	80.0	80.0	80.0
Corn silage			26.7	26.7	26.7	26.7	26.7
Barley			---	---	---	17.0	26.6
Flax			26.6	26.6	26.6	9.6	---
			160.0	160.0	160.0	160.0	160.0
Calves (fed)				20			
Ewes					721	922	937
Lambs (fed)							176
				Dollars			
Operating capital	4,080	4,330	7,628	9,543	26,148	30,449	33,123
Spendable income	1,615	1,900	3,308	3,931	9,004	10,382	10,785
Ration of income to operating capital	39.6%	43.9%	43.3%	41.2%	34.4%	34.1%	32.6%

Nebraska

Nebraska had a contributing project on strategies in organizing and operating farms in the Great Plains area.

Project on Strategies of Organizing and Operating Farms

Proposition--From our experience and knowledge of crop yields, livestock production, and prices, (and their variability), can we determine which farming systems, sizes of farms, tenure of land, and other strategies are best suited to success and farm survival in the Plains?

Objectives--Describe the present pattern of resource use in the Great Plains area, determine the level and variability of various crop and livestock enterprises and combinations on farms of different sizes and tenure, and test other strategies farmers might use to combat uncertainty.

Work Planned

Nebraska planned to assemble data to describe the pattern of resource use; supplement this with farm surveys; analyze crop yields, livestock production, and prices, and their variation for 1920-58; estimate gross and net income variability for each crop and kind of livestock; test various enterprise combinations for income variability; budget representative farms (three sizes and four tenure groups) over time with variable yields and prices; and test the strategies of feed reserves, flexible livestock systems, contract farming, spatial diversification, and substitution of variable for fixed costs (e.g., renting or custom-hiring instead of owning machinery) for their effect on land and variability of income.

Results

The research results of the Nebraska project are reported here under three phases.

Income variability of crops was studied in 41 eastern Nebraska counties for 1943-58, and in Kimball County in western Nebraska for 1917-55 (11). The data used were the annual county average yields of the Federal-State crop reporting services. Two measures of variability were computed: (1) Variance (standard deviation squared) in dollars of gross income per acre, and (2) the coefficient of variation (standard deviation as a percentage of the mean).

The range among the 41 eastern counties--area averages were not computed--in the average gross income per acre, the total variance, and the coefficient of variation for the 16-year period were:

	Number of counties	Gross income per acre (dollars)	Variance (dollars)	Coefficient of variation (percent)
Corn	41	29-54	95-336	24-43
Grain sorghum	41	24-32	90-159	27-53
Soybeans	14	40-49	161-321	27-41
Wheat	28	35-47	133-324	29-41
Oats	28	15-22	18-42	21-37

A wide range in these factors among the counties is readily apparent. The spread in soybeans is smaller, partly because there were only 14 soybean counties. The data emphasize again the point that high-return crops like corn, soybeans and wheat may, and often do, have a larger absolute variability (variance) but smaller relative variability (coefficient of variation), than a lower-return crop, such as grain sorghum.

In Kimball County, in western Nebraska, the variability of gross income of seven crops for 1917-55, was as follows (data in third and fourth columns computed from first and second columns).

	Gross income Per acre	Gross income Variance	Standard deviation	Coefficient of variation
				Percent
Wheat	$21.10	$190	$13.78	65.3
Alfalfa	20.00	99	9.95	49.8
Corn	16.26	149	12.21	75.1
Barley	13.54	70	8.36	61.7
Grain sorghum	10.63	40	6.32	59.4
Oats	10.68	50	7.14	66.8
Rye	9.64	42	6.45	66.9

Wheat had the highest absolute variability, but corn had the highest relative variability. Alfalfa was a high-return crop and it had the lowest relative variability. In Kimball County, year-to-year income variability is much higher for all dryland crops than in eastern Nebraska.

Crop enterprise combinations and their effect on year-to-year income variability were studied in 41 eastern Nebraska counties (11). Combinations of corn and grain sorghum were studied in all 41 counties. In 23 counties, the combination that gave the lowest relative variability (coefficient of variation) was 50 percent of each crop. In another 17 counties, variability was lowest with 75 percent corn and 25 percent grain sorghum. In one county (Pawnee), no combination of corn and grain sorghum had a lower variability than grain sorghum alone. The average gross income and coefficient of variation for each group of counties was as follows:

	Number of counties	Average gross income per acre	Average coefficient of variation
			Percent
Corn-grain sorghum			
75-25	17	$38.33	29.8
50-50	23	34.47	31.8
0-100	1	26.98	31.4

Combinations of corn and soybeans were measured in 14 counties. In seven of these, the lowest relative variability was with 100 percent corn; the addition of soybeans did not reduce the variability. In one county, the lowest variability was with 75 percent corn, 25 percent soybeans; in five counties, it was with 50 percent corn, 50 percent soybeans; and in one county (Colfax), it was 25 percent corn--75 percent soybeans. Average returns and variability for these combinations were as follows:

	Counties	Average gross income per acre	Average coefficient of variation
			Percent
Corn-soybeans			
100-0	7	$47.02	28.4
75-25	1	41.59	38.1
50-50	5	46.34	30.9
25-75	1	43.25	38.7

Wheat-oat combinations were studied in 28 counties. In all but one (Hamilton), the lowest relative variability was 25 percent wheat, 75 percent oats. In Hamilton, the lowest was half wheat and half oats. For the 25-75 combination in the 27 counties, the gross return averaged $23.56 an acre, and the coefficient of variation averaged 25.0 percent.

In Kimball County, western Nebraska, the combination of wheat and corn having the lowest variance was 30 percent wheat, 70 percent corn (gross $20.21; C.V. 47.7). No combination of wheat-barley, wheat-oats, or wheat-grain sorghum had a lower income variance than barley, oats, or grain sorghum grown alone.

In both eastern Nebraska and in Kimball County, the lowest variances were achieved in general only at a sacrifice in average gross income.

Hay reserves as a stabilizing strategy was studied in Sherman, a county in the transition area between the Corn Belt and Plains. The question was whether net income would be stabilized over time by holding the cow herd to the average carrying capacity of the range, and carry the surplus forage from the good years as hay for supplementing the short range in poor grass years. This is called a stabilized livestock system. If hay reserves were not used, the cow herd would be adjusted to the actual carrying capacity year by year. This would be called a flexible system. Both systems were analyzed on a 480-acre farm, for the 38 years (1920-57), which included the prolonged droughts of the 1930's and the 1950's. In the stabilized system, the cow herd remained at 35 brood cows. In the flexible system, the cow herd was adjusted to a 3-year moving average of forage production. To isolate the "yield" effect on income, prices were held constant for the study period.

Budgeted incomes under the two systems can be summarized as follows:

	Feed reserves and stable livestock system	No feed reserves and flexible livestock system
Cumulative, 38 years	$33,682	$42,082
Average, 38 years	$886	$1,108
Highest year	$2,057	$3,465
Lowest year	$-426	$-1,523
Years with deficit income (number)	8	11
Standard deviation	$730	$1,398
Coefficient of variation (percent)	82.5	126.2

Annual gross income varied much less under the stabilized system neither rising as high nor falling as low as under the flexible system. However, gross returns averaged 25 percent lower than under the flexible system. Partly because of this, there were only 3 more years (11 versus 8) out of 38 in which the flexible system resulted in a net cash loss. Many farmers would not consider this degree of stability worth the sacrifice in average income.

Kansas

Project on Economic Opportunities and Strategies

Proposition--How can farmers choose among enterprises, production technology, contract farming, and off-farm work so as to improve their incomes and adjust to economic and environmental uncertainty?

Objective--To provide economic information to help farmers make adjustments by--

(1) Describing the present farm situation,

(2) Determining the variability of rainfall, and of crops individually and in combination,

(3) Determining the effect on income and its variability of such strategies as choice of enterprise, production technology, contract farming, and off-farm work,

(4) Appraising the effect of alternative strategies on production costs and return.

Work Planned

Kansas planned to explore and appraise the current situation as to production alternatives in western Kansas; analyze the year-to-year variation in rainfall and crop yields for 41 years; analyze different enterprise combinations for their effect on farm income over time; analyze production technologies used by progressive farmers, also anticipated new technologies, for their effect on capital accumulation and farm survival; analyze the impact of contract farming on the variability and level of farm incomes; and analyze the impact of off-farm employment on capital accumulation.

Kansas also planned to project the number of new farming opportunities in each 5-year period to 1975.

Results

One phase of the project concerned the effect of certain variables--soil moisture at seeding time, rainfall during the growing season, and nitrogen and phosphorus fertilization--on grain sorghum yields on sandy soils in southwestern Kansas (32). Data were from farmer cooperators in 1951-56. The experiment included 14 fertilizer treatments and 8 moisture levels, with 4 or 5 replicates per treatment--382 observations in all.

It was found that soil moisture at planting time was more important than seasonal rainfall or fertilizer on ultimate crop yield. Response to soil moisture within the range of 24 to 60 inches indicated increasing returns. Experiments beyond the 60-inch depth would add to our information. Yield response to growing-season moisture was positive and more pronounced at heavy applications of nitrogen than at light applications. Yield response to nitrogen was positive, and it varied with soil moisture at seeding time and with growing-season rainfall. The direction of response was expected, but the magnitudes were new information. Response to phosphorus was negligible under any and all moisture conditions.

A yield-predicting equation, developed from the analyzed data, produced the following selected results:

Depth of soil moisture at seeding time	Rainfall during growing season	Pounds of nitrogen per acre				
		0	20	40	60	80
Inches	Inches	Grain sorghum yield (bu. per acre)				
24	2	6.6	7.4	7.6	7.7	7.7
24	8	11.2	13.9	15.9	17.2	17.7
36	2	13.2	14.8	15.2	15.4	15.6
36	8	19.2	22.8	24.8	26.6	27.5
48	2	21.8	24.3	24.9	25.3	25.6
48	8	27.1	27.4	33.7	35.9	37.4
60	2	32.0	35.7	36.6	37.2	37.6
60	8	35.1	39.1	42.6	45.2	47.2

Not included here are estimates for 4 inches and 6 inches of growing season rainfall and for 10, 30, 50, 70, and 90 pounds of nitrogen. Yields from 90 pounds were almost identical to those of 80 pounds of nitrogen.

Another phase of the project concerned the year-to-year variability of crop yields and their cause (32). County average grain sorghum yields were studied for 29 counties during the 41-year period, 1916-56. A mathematical model was developed for measuring total variance and the components due to specified variables. Variance due to type-of-farming area, county, and year was computed. As expected, the chief component of variation was "year" which in this case included such non-specified variables as varieties, dates of planting, rainfall, hail, insect damage, and other hazards. About 50 percent of the variability due to years could be charged to rainfall. Because differences in average yields of adjacent counties were small the researchers concluded that spatial diversification would not be a promising strategy to reduce the year-to-year variability in a farm's total output, at least not in Kansas. A more extensive analysis of individual farm yields rather than county yields might modify this conclusion.

Still another phase of the project concerned a projection of future farming opportunities in western Kansas (30). As farms become larger and fewer, what is the outlook by 1975? The supply of farming opportunities will be affected by change in farmland, size of farms, migration out of farming, deaths among operators, farms with more than one operator, and hired labor. Demand for farming opportunities will depend upon the birth rate of rural males, migration of farm youth, and death rate of rural males under age 20.

If current (1950-60) trends continue, the number of farming opportunities will decrease from 19,908 to 16,857, or -15.3 percent. If trends continue but workers increase from 1.3 to 1.5 per farm, then opportunities will decrease from 22,673 to 19,279, or -15 percent. If farm consolidation rate should double the current rate, the number of opportunities will decrease from 18,356 to 14,157, or -22.9 percent. Since western Kansas is mostly rural, the "surplus" youth will seek employment outside the area. Loss of population means adjustment in schools, in local government services, in churches, and in other community services; it means changing consumer

spending patterns--fewer farmers may each buy more fertilizer, better housing, and more appliances, but fewer personal necessities.

Oklahoma

Oklahoma had a contributing project (cooperative with ERS) on alternative systems of farming and ranching in the high-risk area of northwestern Oklahoma.

Project on Farm Organization

Proposition--If we learn the income variability of individual crop and livestock enterprises and their combinations, can we find the best farm organization suited to land and climate?

Objective--To determine the organization of resources best suited to climate and land by determining:

(1) The present pattern of farming,

(2) The income variability of each crop and livestock enterprise,

(3) The average long-term income from alternative organizations, different size units, equity, and tenure situations,

(4) The degree of income variability associated with each situation studied under (3),

(5) The business survival probabilities of resource organizations under (3).

Work Planned

Oklahoma planned to take survey records to describe present patterns of resource use and farming practices on typical farms; compute average crop yields and livestock output and their variability, using experimental and survey data; compute income variability under (a) yield variance and fixed prices, (b) both yield and price variance; compute normal income expectations for selected patterns of resource organizations; estimate income variability of systems; compute survival probabilities to cover (a) family living, (b) fixed business expense (machinery repairs, tractor fuel, seed, feed, etc.), to include runs of good years and poor years; and appraise various means of maximizing survival probability for various situations, including (a) strategies farmers can use in their own operations (flexibility, product diversification, feed reserves, financial reserves, tenure choice, spatial diversification of farm organizations, and low-risk enterprises) and (b) strategies outside their operations (crop insurance, price guarantees, flexible loan repayments).

Results

Economic returns, production costs, and the resources required were compared for various crop and livestock enterprises in the Rolling Plains of northwestern Oklahoma (13). Estimates were based on station experiments, farmers' experience, evaluations by scientists, and other sources of information, and were for five productivity classes of land, with 1960 prices: wheat, $1.62 (bu.); barley, $0.86 (bu.); grain sorghum, $1.60 (cwt.); forage sorghum, $20 (ton). Estimates of annual returns above variable costs per acre on class-A land without a charge for labor were:

Harvested crops, per acre	Annual returns above variable costs (excluding labor)
Wheat	$15.81
Wheat-fallow	11.65
Wheat-grain sorghum-fallow	12.13
Grain sorghum	9.34
Barley	9.32
Forage sorghum	22.72

The figure for wheat-fallow is a 2-year average; the one for wheat-grain sorghum-fallow is a 3-year average.

For six forage grazing crops, estimates were made of production per acre in animal unit months (a.u.m. equals 1 month's grazing for one mature cow), cost per acre, and cost per a.u.m.

Grazed forage, per acre	Production	Total costs, except labor	Average cost per a.u.m.
	A.U.M.	Dollars	Dollars
Wheat	2.90	2.89	1.00
Sudangrass	1.70	1.81	1.06
Forage sorghum	1.30	2.28	1.75
Johnsongrass (10 yr. av.)	1.90	.66	.35
Weeping lovegrass	2.50	2.08	.83
Sandyland mixture (10 yr. av.)	1.10	.87	.79

Net returns were estimated for six different situations of buy-sell stocker and feeder cattle, and for three situations of cow-calf enterprises. The situations differed as to purchase and sale dates, and as to length and type of grazing. Annual net returns above variable costs for three selected systems were as follows:

Per head	Returns above variable costs	
	Excluding labor	Including labor
Fall: buy calves - fall: sell feeders (native range, forage sorghum)	$25.10	$14.48
Spring: buy calves - fall: sell feeders (native range)	21.03	16.53
Cow-calf (calf born March 1) (native range, forage sorghum)	41.40	25.70

A second phase of the study concerned the production and income variability of farm enterprises in northwest Oklahoma (<u>12</u>). Because we lacked data for individual farms, experiment station yields were used to show year-to-year variability, and county average yields for 1942-57 to represent the farm level. Variation was measured as the coefficient of variation--i.e., the standard deviation as a percentage of the mean. Average production, gross income, and net cash returns--and the relative variability of each--for the study period are summarized as follows:

	Wheat	Grain sorghum	Stocker-steer	Beef cow-calf	
Production per acre					
Mean	12.5 bu.	10.9 bu.	39.1 lb.	23.9 lb.	
Standard deviation	4.1 bu.	5.6 bu.	9.0 lb.	1.0 lb.	
Coefficient of variation	33.1 pct.	51.6 pct.	22.9 pct.	4.2 pct.	
				Calves	Cull cow
Prices (deflated)					
Mean	$1.02	$0.68	$9.75	$9.38	$7.11
Standard deviation	.09	.19	2.21	2.12	1.89
Coefficient of variation	8.8 pct.	27.9 pct.	22.6 pct.	22.6 pct.	26.6 pct.
				Beef cow-calf	
				Constant cow-herd values	Variable cow-herd values
Gross income per acre					
Mean	$12.82	$7.06	$3.50	$2.29	$2.43
Standard deviation	4.51	3.32	1.94	.65	1.38
Coefficient of variation	35.2 pct.	47.0 pct.	55.4 pct.	28.4 pct.	56.8 pct.
Net return above cash costs per acre					
Mean	$10.30	$5.11	$2.73	$1.65	$1.79
Standard deviation	4.45	3.32	1.92	.62	1.39
Coefficient of variation	43.2 pct.	64.9 pct.	70.2 pct.	37.9 pct.	77.5 pct.

Wheat varied more than beef enterprises in production, gross income, and net returns, but varied less in price. The stocker-steer enterprise varied more than the cow-calf enterprise in production (22.9 percent versus 4.2 percent) if we ignore inventory changes. However, because prices varied so much, the gross income and net returns were more variable for the cow-calf than for the stocker-steer enterprise in which buying and selling usually are on the same general price level.

Bunchiness was found for each of 3 tests (runs, 4-year moving average, and nonparametric statistical test). Incomes tended to bunch more than yields. Shown below for each enterprise is the longest period that crop yields, livestock production, and rainfall were less than 85 percent or more than 115 percent of the average.

Years	Enterprise	Number of years	Less than 85 percent of average	85 to 115 percent of average	More than 115 percent of average
			Years	Years	Years
1914-57	Grain sorghum	44	7	2	7
1922-57	Wheat	36	4	3	2
1942-57	Steers	16	2	1	2
1942-57	Cow-calf	16	0	16	0
1885-57	Rainfall	73	3	5	2

Correlations: Yields of wheat were not related to grain-sorghum yields, nor to livestock production from native range. Given a favorable year for wheat, the probabilities are about equal for a good, bad, or indifferent year for grain sorghum, steer, or cow-calf production. Wheat has a different growing season than grain sorghum and livestock. However, gross returns and net returns per acre of grain sorghum are not significantly correlated with returns from livestock enterprises per acre of native range. Production, prices, and returns for steer and cow-calf enterprises correlate closely.

In a third phase, beef production on various types of grazing forage was studied for 1942-57. The data were adapted largely from experiments at the Woodward, Okla., station. Results for buy-sell steer systems and from cow-calf systems were as follows:

Types of forage and enterprise	Average per acre	Standard deviation	Coefficient of variation
	Pounds	Pounds	Percent
Native grass			
Heavy graze, steers	47.53	9.43	19.84
Moderate graze, steers	39.14	8.98	22.94
Moderate graze, cow-calf	23.95	.99	4.15
Johnsongrass			
Steers	88.79	17.41	19.61
Cow-calf	57.58	2.07	3.60
Sudangrass			
Steers	83.85	28.59	34.10
Cow-calf	49.85	3.14	6.30
Wheat (Oct.-Feb.)			
Steers	11.24	5.43	48.28
Cow-calf	6.66	.59	8.86
Wheat (Mar.-May)			
Steers	137.73	32.49	23.59
Cow-calf	82.13	3.55	4.33

Note that beef production was generally greater on the introduced grasses--Johnsongrass and Sudangrass--than on native grass, and greater on spring (March-May) grazing of winter wheat than on winter grazing. The consistently lower turnoff of beef from the cow-calf system than from the stocker-steer system reflects the forage input needed for animal maintenance in cattle raising. However, the year-to-year variability of beef turnoff was also lower for the cow-calf enterprise.

In the same study, the economics of cash-crop and cattle-grazing enterprises was studied on five farm-resource situations described as follows:

Type of farm	Total acres	Cropland acres	Wheat allotment	Native range
Small balanced	640	320	160	288
Small range	1,600	320	160	1,200
Large balanced	1,920	960	480	864
Large range	2,640	160	80	2,348
Large crop	1,400	1,240	620	90

These farms were programmed for maximum returns, using average production for 1943-57; then the variability was computed, using annual yields for the period. Altogether, there were 19 resources and 80 activities in the program.

Cash-grain crops included continuous wheat, wheat-fallow, wheat-grain sorghum-fallow, grain sorghum, and barley. Crops for grazing included forage sorghum, Sudangrass, Johnsongrass, weeping lovegrass, sandyland mixture wheat grazed out, and "go-back" grass. The only harvested forage was forage sorghum. Livestock enterprises included five buy-sell steer operations and three cow-calf operations. Some programs excluded all steers, some excluded temporary steer grazing, and some had no restrictions. The resulting optimum plans for two situations on the five farms were as follows:

Type of forage and enterprise	Small balanced	Small range	Large balanced	Large range	Large crop
Restricted to cow-calf:					
Wheat, acres	160	160	480	80	620
Grain sorghum, acres	48	63	193	28	186
Forage sorghum, acres	1	5	4	10	1
Fallow, acres	47	63	193	28	186
Cropland pasture, acres	64	29	90	14	247
Cows, number	26	77	61	148	31
Gross returns, dollars	7,014	11,888	20,413	15,746	20,959
Stand. dev., dollars	1,690	2,927	5,026	4,210	5,450
Coef. of var., percent	24.1	24.6	24.6	26.7	26.0
Cattle, unrestricted:					
Wheat, acres	160	160	480	80	620
Grain sorghum, acres	---	---	---	---	10
Forage sorghum, acres	2	7	19	10	17
Fallow	---	---	---	---	10
Cropland pasture, acres	158	153	461	70	583
Steers, number	123	248	278	456	204
Gross returns, dollars	10,178	18,744	27,352	26,432	26,727
Stand. dev., dollars	4,832	10,102	10,780	16,506	9,234
Coef. of var., percent	47.5	53.9	39.4	62.4	34.6

Note that each farm grows its allotted acres of wheat; wheat priced at $1.67 a bushel is not replaced by cattle. When the cattle enterprise is restricted to cow-calf, the wheat is grown on fallow in rotation with grain sorghum (for sale). Any land remaining is used for pasture and forage sorghum to supplement the native range in support of the cow-calf enterprise. But if a stocker-steer enterprise is permitted, the wheat allotment is grown without fallow, no grain sorghum is grown, and all the remaining cropland is used for pasture and forage sorghum to supplement the native range. Stocker steers do displace fallow for wheat and grain sorghum for sale. These results indicate that buy-sell steer operations are more profitable than cow-calf for all five farm situations, but they also have much greater year-to-year variability of income.

In still another phase, the effect of changes in product prices on farm organization and income were studied on a 1,280-acre dryland farm, on clay soil in southwest Oklahoma. Budgets were based on five prices for cotton, three for wheat and beef cattle, and two charges for capital. At the base prices for wheat ($1.25) and beef cattle (stocker steers at $21), cotton is not produced when its price is 22 cents a pound or less; production of wheat and cattle is maximized. Stocker steers are more profitable than a cow-calf raising enterprise. Cotton at 26.4 cents (20 percent above the base) becomes a major enterprise replacing much of the wheat and cattle, and at 30.8 cents replaces still more of them. With wheat and cattle prices 30 percent below the base, cotton enters the organization when its price reaches 17.6 cents, and replaces most of the wheat and cattle when its price reaches 22.0 cents (the base). When wheat and cattle prices are 30 percent above the base prices, their production is maximized and cotton does not enter the organization until its price reaches 30.8 cents (40 percent above the base), at which it replaces about half the wheat and 13 percent of the stocker steers.

Texas

Texas had a contributing project (cooperative with ERS) on strategies for organizing and operating farms and ranches in the Plains.

Project on Strategies for Organizing and Operating Farms and Ranches

Proposition--What are the strategies for organizing and operating dryland row-crop farms and ranches in the Plains to meet variable climatic and changing economic conditions?

Objectives--To describe the level and variability of income for alternative enterprises and farming systems, and to evaluate alternative strategies in organizing and operating farms in the High and Rolling Plains, toward the goals of capital accumulation and survival.

Work Planned

Texas planned to assemble data on crop yields and costs of production for each enterprise; supplement this with farm surveys as needed; estimate the average income for each enterprise, for combinations of enterprises, and for whole farms of various sizes, and see how these vary over time; analyze certain crops with alternative prices; estimate the variance and covariance of each pair of enterprises; and

analyze the use of various strategies in achieving goals of capital accumulation and farm survival for representative farms. Strategies to be considered were production technologies, choice of enterprises, flexible livestock systems, feed reserves, and financial management.

Results

In one phase, the average level and variability of yield and reinvestable income (gross minus all costs, including depreciation) were measured for cotton and grain sorghum (28). The data were records of 30 years' (1927-57) dryland yields at the Lubbock Experiment Station. Average net income was estimated at $37.18 an acre for cotton--more than twice the average--and $16.40 for grain sorghum. However, the relative variability in net income was less for cotton (C.V. 63 percent) than for grain sorghum (73 percent).

Two nonparametric statistical tests were applied to the yield data from the Big Springs Experiment Station to detect bunchiness or recurring cycles in yields or reinvestment income. Five different types of "runs" were tested: (1) any change in direction of the original data, (2) changes in direction of a 4-year moving average, (3) any sequence of years when the values fall above, below, or within 0.3 standard deviation, or (4) for 0.5 standard deviation, or (5) for 0.8 standard deviation. Regular recurring cycles were found in cotton yields but not in grain sorghum or in reinvestment income assuming constant prices. Considerable bunchiness was found in grain sorghum yield and incomes at constant prices. If there is a tendency for bunchiness of "good" and "bad" years in the Southern Plains, and if capital accumulation is the goal (rather than survival), then flexibility is the most promising strategy for farmers. It would permit them to withhold cash inputs as long as possible to see what kind the year will be.

In another phase, crop diversification was studied as a strategy, using cotton and grain sorghum as alternate crops. Annual net income varied least when 44 percent of the cropland was in cotton and 56 percent in grain sorghum. However, little income stability was sacrificed when the cotton acreage was raised to 60 percent and grain sorghum lowered to 40, and average net income was greatly increased.

Finally, the economics of cotton-grain sorghum combination (crop diversification) was studied under cotton acreage allotments. On a farm of 300 acres of cropland and with 120 acres of cotton allotment, a skip-row system of two rows in cotton and two rows out (2x2) was found more profitable than the 2x1 row system or the solid 40-inch row system. The most profitable system was 210 (geographic) acres of cropland occupied by cotton, using the 2-in, 2-out system, and the remaining 90 acres in grain sorghum. This system returned about $3,400 more net income than the soild 40-inch row system, and about $850 more than the 2x1 system.

Economic Research Service

The Economic Research Service had a contributing project (cooperative with Montana) on the effect of weather on management strategies for dryland farmers in Montana. In addition, ERS had a cooperative project with New Mexico on ranch production adjustments to drought in the eastern Plains of New Mexico, and a cooperative project with Kansas on the adjustments made in livestock enterprises during drought

in western Kansas. Neither the New Mexico or Kansas studies were formally designated as contributing projects to the regional GP-2 project.

Project on Effect of Weather on Management Strategies

Proposition--How does year-to-year variation in Montana weather affect the management strategies dryland farmers can use in adjusting the organization and operation of their farms? How are such strategies affected or limited by the resources of the farmer, his knowledge, attitudes, and opinions, and by the social and institutional environment in which he lives and operates? Can appropriate strategies be combined into a decision-making model of financial management?

Objectives--Develop appropriate management strategies for Montana dryland farmers, develop a model for financial management, test individual strategies, examine institutional forces from the managerial viewpoint, and suggest socio-economic institutions in better agreement with the desirable individual strategies and acceptable socioeconomic norms.

Work Planned

ERS planned to develop input-output coefficients for production from other research in progress; develop a management paradigm--a general model not specifically representative of any farming situation--in which production input-output coefficients, resources, and financial management tools can be combined into acceptable decision-making models; test selected management strategies by incorporating them into the management paradigm, with crop yields (and weather) as independent variables; inventory the ways in which social institutions--bank credit, crop insurance, etc.--impinge upon the individual choices among management strategies; by means of personal interview surveys, determine the accepted norms among farmers in the use of bank credit and the accepted norms among lenders in the granting of credit; determine whether customs in lending limit the use of credit and hence limit the management strategies available to dryland farmers; and determine the amount of financial and other reserves needed by representative individual farmers to meet variable expenses of the farm and household. Not all of these goals were met by the time the project was revised.

Results

An early phase of the project concerned the year-to-year variability of wheat yields in north-central and northeastern Montana (5). Farm yields were found to vary more than county average yields, but historical series for individual farms are scarce. Data approximating farm yields were found in the official lease records of State-owned land beginning in 1939. Altogether, 2,113 observations for winter wheat and 2,895 for spring wheat were obtained in 4 counties in the 2 areas. An example of the difference in farm and county data follows:

	Years	Average yield	Variance	Standard deviation	Coefficient of variation
	No.	Bu.	Bu.	Bu.	Pct.
Farm 1	18	14.6	111.53	10.56	72.3
Farm 2	15	22.4	59.44	7.71	34.4
Farm 3	18	26.4	60.67	7.66	29.0
Judith Basin County	17	16.4	12.60	3.55	21.6

The State land-lease data were used to study the probability of extreme yields, both high and low. To this problem was applied the extreme-value theory of statistical distributions, based on normally distributed observations. A mathematical equation expresses the probability that any one observation will be less than, or conversely more than, a specified amount when the data are drawn from an experience distribution. The theory was used to compute the probability that a Montana wheat farmer in a given year would obtain a yield sufficient to cover specified farm or family living costs. Computations were made for small, medium, medium-large, and large farms for both winter wheat and spring wheat in Fergus and Judith Basin counties, and for spring wheat only in Roosevelt and Sheridan Counties.

In another phase, the relation between size of farm and yield variability was studied in the same four counties individually for 1939-42. Variability among farms decreased about half as the wheat acreage per farm increased from 100 to 1,000 acres. For example, in Judith Basin and Roosevelt Counties the coefficients of variation were as follows:

Location and year	Less than 100 acres	Over 900 acres
	Percent	Percent
Judith Basin County:		
1939	50	24
1940	71	31
1941	46	19
1942	33	16
Roosevelt County:		
1939	51	24
1940	52	21
1941	45	23
1942	34	16

Year-to-year variability in "farm average yields" was smaller on the larger farms because they include a wider range of conditions to be averaged.

An association was found between wheat yields and size of farm. The mean average yield increased significantly with acreage up to about 600-800 acres, and then decreased. The mean yield was 2-4 bushels an acre higher for the medium-size farm than for the small or larger farms. There was no explanation for this, except possibly an improvement in management up to an optimum acreage.

In another phase, the Markov chain process was used to study the relation between yields in succeeding years. Such a relation seems reasonable since rainfall one year may influence, through carryover soil moisture, the yield next year. Markov chain is a statistical test for the significance of changes in probabilities in the following year. Farms in northeastern Montana were sorted into five wheat-yield groups for one year and the distribution of yields the following year were as shown below. The data include 612 observations; many were used twice--once as year "one" and again as year "two."

If the yield this year is--	The probabilities are that next year's yield will be--				
	Under 4.0 bu.	4.0 to 7.1 bu.	7.2 to 18.1 bu.	18.2 to 20.8 bu.	20.9 bu. and over
Under 4.0 bushels	0.135	0.135	0.378	0.108	0.243
4.0 to 7.1 bushels	.093	.204	.611	.018	.074
7.1 to 18.1 bushels	.039	.095	.576	.099	.191
18.2 to 20.8 bushels	.015	.015	.470	.176	.324
20.0 or more bushels	.034	.027	.288	.168	.483
Longrun average	.043	.077	.476	.122	.282

Note: The yield classes are irregular, being designed to cover specified categories of farm and family expenses.

Results indicate that the probabilities for next year's yield differ depending upon the actual yield obtained this year. For example, if this year's yield was below 4.0 bushels an acre, the probability of getting another low yield next year is 0.135, which is greater than if this year's yield had been higher. The longrun probability for a yield below 4.0 bushels is only 0.043.

In another phase, the use of production credit among dryland farmers was studied (6). A sample of farmers, commercial bankers, production credit associations, and Farmers Home Administration offices were interviewed. Questions were asked regarding those attributes of borrowers deemed most important in granting loans. Seventeen attributes were ranked by the lending agencies and nine by the borrowers. All three types of lenders ranked "ambition," "management practices," "farming experience," and "loan history" among the first five, but placed them differently. The rankings were tested for significance using the Guttman Scale, a method commonly used by sociologists and phychologists, but thus far little used by economists. Based on the study, the researchers listed the following as the more successful strategies a farmer might use in obtaining loans:

Know the lender,

Establish a loan history,

Have a realistic farm plan,

Be prepared to bargain,

Shop around (among lenders).

In another phase, financial reserves were studied as a managerial strategy for dryland wheat farmers in Montana (14). Year-to-year income budgets for a 1,640-acre farm were constructed, using 37 different crop-yield series in the Triangle area and 30 in the northeast, varying in length from 14 to 24 years, all of them ending in 1956. Each series was from an actual farm that had leased State-owned land. Average yield varied from 6.2 to 17.5 bushels an acre in the northeast and from 14.1 to 29.3 in the Triangle. Coefficients of variation ranged from 36.0 to 64.8 percent in the northeast and from 30.6 to 60.4 percent in the Triangle. Maximum reserves

needed to meet farm and family expenses in the poorest stretch of years ranged from $472 to $35,500 among the 30 yield series in the northeast, and from zero reserves to $41,061 among the 37 series in the north-central area.

Another phase concerned the management strategies of beginning farmers (21). Two hundred dryland farmers were interviewed in 1960 to learn how they had secured land and how they had progressed. Starting periods were defined as pre-1940, 1940-50, and 1950-60. Those who began in period I homesteaded or purchased much of their land. Starters in period II rented more land than they bought, and in period III, renting became the dominant source of land. Starters turned to renting because farm size, capital requirements, and operating expenses had increased. Though more recent starters had more beginning assets, they were needed as operating expenses. Renting likewise became an increasing avenue to farm enlargement for the starters of each period. Hence, part ownership has become the dominant tenure form:

	Number of operators	
	Starting	In 1960
Triangle:		
Full owners	47	18
Part owners	27	63
Full tenants	19	12
Northeast:		
Full owners	35	23
Part owners	33	60
Full tenants	31	16

Actually, the investment in dryland grain farms has become so large that operators starting with small equities find it hard to meet the large amortization payments out of annual earnings. If the payments exceed the "economic rent" of the land, as they may, then part of the amortization must come from labor earnings or business profits. Consider the 1,156-acre crop farm in the Montana Triangle whose value was $129,202 in 1960. Compare the situation of a full owner (land equity, 20 percent; machinery, 30 percent) with a full tenant (machinery, 30 percent) as follows:

	Full owner	Full tenant
	Dollars	Dollars
Assets:		
Land and buildings	112,547	---
Machinery	16,655	16,655
Total	129,202	16,655
Gross income	14,655	10,991
Cash expenses (including $2,400 family living)	6,095	5,747
Net cash	8,560	5,244
Annual payments:		
Land	6,195	---
Machinery	2,782	2,782
Total payments	8,977	2,782
Net cash after payments	-417	2,462
Depreciation	2,413	2,413
Interest on equity	1,543	305

The owner having a land equity of only 20 percent was, on the average, unable to meet the annual mortgage and cover his depreciation or have a return on his equity. Only the larger farm operators having larger equities were able to meet the amortization payments out of earnings.

Still another phase of the project concerned crop insurance as a management strategy (20). Dryland farmers were interviewed to learn their use of and attitudes toward all-risk and crop-hail insurance. The all-risk insurance is offered by the Federal Crop Insurance Corporation at premiums sufficient to cover standard production costs, not to exceed the value of 75 percent of the average yield of the insured farm. Insurance contracts must predate the production season. Crop-hail insurance is offered by commercial companies, at up to full coverage, any time before harvest, at appropriate premiums. How interviewed farmers ranked the natural hazards in dryland farming is shown below. (The numbers represent a numerical scale of attitudes based on paired-comparisons, all-risk crop insurance, insurance users, Triangle area = 1.00.)

Triangle winter wheat area

Insurance users		Nonusers	
All-risk	1.00	All-risk	0.79
Drought	.79	Drought	.70
Hail	.76	Hail	.53
Winterkill	.38	Winterkill	.42
Insects-disease	.19	Insects-disease	.16
Wind or flooding	.02	Wind or flooding	.02

Northeast spring wheat area

Insurance users		Nonusers	
Drought	1.00	All-risk	0.81
Hail	.98	Drought	.79
Insects-disease	.31	Hail	.62
Wind or flooding	.07	Insects-disease	.36
		Wind or flooding	.17
		Winterkill	.02

Finally, the ERS project included an effort to develop a paradigm (fig. 2, p.25). A paradigm is a general model, not intended to represent any specific farming situation. It is a structure into which a specific representative farm can be cast for solving problems of financial management over time. Attempts were made to design a paradigm that would accommodate different resources, production processes, levels of beginning equities, physical and financial reserves, crop insurance, production credit, land buying and renting arrangements, off-farm work, and other management strategies. Inputs into the process could include different year-series of yields and prices. The paradigm would provide for accumulation and "feed-back" processes. As yet a completely workable paradigm of the type described has not been achieved.

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APPENDIX

ABSTRACTS OF SELECTED RESEARCH PUBLICATIONS FROM THE CONTRIBUTING PROJECTS 7/

Abstracts are provided to associate the research results with the published reports, which readers may wish to obtain for additional details and further study.

Bostwick. STUDIES IN YIELD VARIABILITY. Mont. Agr. Expt. Sta. Bul. 574, Jan. 1963.

Results of a three-part study are reported including the formulation of hypotheses tested, the data obtained, and the tests used. Analyzed and discussed in turn are: Yield probability as related to farm management; yield variability of individual farms versus groups of farms; probability functions including extreme value statistical distributions; variability as related to size of farm and to dispersion of land units within a farm. (5)

Bostwick, Esmay, and Rodewald. AGRICULTURAL PRODUCTION CREDIT IN MONTANA. Mont. Agr. Expt. Sta. Cir. 233, Apr. 1961.

Commercial banks, production credit associations, and Farmers Home Administration are discussed and compared as to source of loan funds, type and term of loans made, and rates of interest charged. A survey of farmers' and lenders' attitudes which affect the availability and use of credit by dryland grain farmers, is reported. The strategies which farmers might use to improve their chances of borrowing the funds they need and can use wisely, are described and discussed. (6)

Bostwick, Esmay, and Rodewald. ATTITUDINAL RESEARCH RELATING TO FARMERS' USE OF SHORT-TERM CREDIT. ERS-25, Oct. 1961.

Three techniques--Guttman scalogram, rank correlation, and paired comparisons--are used to measure the attitudes of dryland wheat farmers toward the use of production credit. Data are from interviews with 250 farmers. Analytical procedures including tests of significance are explained. Results from each method are compared and appraised. Interview questions used are listed in an appendix. (7)

Finley. THE INFLUENCE OF ACREAGE AND YIELD CHANGES ON CROP PRODUCTION IN NEBRASKA. Nebr. Agr. Expt. Sta. Res. Bul. 212, Oct. 1963.

Year-to-year changes in production of five crops--winter wheat, oats, corn, soybeans, and grain sorghum--in Nebraska are studied and the proportion due to changes in yield and changes in acres, is analyzed. Data are from the State-Federal Crop Reporting Service. (10)

Finley. RISK AND INCOME RELATIONSHIPS AMONG COMPETING CROPS IN EASTERN NEBRASKA. Nebr. Agr. Expt. Sta. Agr. Econ. Rpt. 29, Feb. 1963.

Year-to-year variability in gross income is computed for 5 crops--corn, soybeans, grain sorghum, wheat, oats--in 41 counties, using 1943-58 county average yields and

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7/ Complete citations are in the Bibliography, p. 48. Each abstract ends with the number of the corresponding Bibliography entry in parentheses.

prices. Average gross income, its variance, and coefficient of variation are computed for each crop in each county where grown. The same measures are computed for crops (corn-soybeans; corn-grain sorghum; wheat-oats) combined in various proportions--100-0, 90-10, 80-20, etc. (11)

Finley and Langemeier. THE STRATEGY OF HAY RESERVES AS AN INCOME STABILIZER. In Management Strategies in Great Plains Farming. Nebr. Agr. Expt. Sta. MP-7. Aug. 1961.

Annual production and income are budgeted for a stabilized and a flexible cow-calf enterprise on a 480-acre farm model in Sherman County for 1920-57, using constant prices. In the stabilized operation, the cow herd is held constant, and the surplus forage from "good" years is stored for use in "bad" years. In the flexible operation, the cow herd is adjusted to a 3-year moving average of actual forage production. Net incomes are analyzed for average, standard deviation, and coefficient of variation, and for number of years showing a net loss. (1)

Greve, Plaxico, and Lagrone. PRODUCTION AND INCOME VARIABILITY OF ALTERNATIVE FARM ENTERPRISES IN NORTHWEST OKLAHOMA. Okla. Agr. Expt. Sta. Bul. B-563. Aug. 1960.

Production and income budgets are computed annually for wheat, grain sorghum, stocker (buy-sell) steers, and cow-calf enterprises. Experiment station crop and forage yields are used as a measure of year-to-year variation and county average yields for 1942-57 to represent the farm level. Three price assumptions were used: yearly prices received by farmers, historical prices deflated to 1935-39 average, and constant prices. The mean, standard deviation and coefficient of variation are reported for production, prices, gross income and net income of each enterprise. Also correlation of these factors between enterprises. (12)

Greve, Plaxico, and Lagrone. RESOURCE REQUIREMENTS, COSTS, AND EXPECTED RETURNS; ALTERNATIVE CROP AND LIVESTOCK ENTERPRISES; ROLLING PLAINS, NORTHWESTERN OKLAHOMA. Okla. Agr. Expt. Sta. Proc. Ser. P-390. Aug. 1961.

Various crop and livestock enterprises are compared as to resources required, costs of production, and returns. Estimates are constructed from experiments, farmers' experience, evaluations by scientists, and other sources, for four separate productivity classes of land when crop prices are: wheat, $1.62 (bu.); barley, $0.86 (bu.); grain sorghum, $1.60 (cwt.); and forage sorghum, $20 (ton). Income estimates are for returns above variable costs with and without a charge for labor. Enterprises are wheat, wheat-fallow, wheat-grain sorghum-fallow, grain sorghum, barley, forage sorghum. For six forage crops, estimates are for production per acre in animal months (AUM), cost per acre, and cost per AUM. The grazed forages: wheat, Sudangrass, forage sorghum, Johnsongrass, weeping lovegrass, and sandyland mixture. (13)

Hjort. THE USE AND EFFECTIVENESS OF FINANCIAL AND PHYSICAL RESERVES IN MONTANA'S DRYLAND WHEAT AREA. Mont. Agr. Expt. Sta., Dept. Agr. Econ. and Rural Sociol. Aug. 1959.

Year-to-year income budgets are constructed for a 1,640-acre dryland wheat farm, using 37 different yield series in the north-central area and 30 series in the northeast area. Each yield series is from an actual farm, varying in length from 14 to 24

years, all ending in 1956. Maximum financial reserves needed to carry the farm and family over the worst drought periods are computed. (14)

Jensen and Nash. FARM UNIT DISPERSION--A MANAGERIAL TECHNIQUE TO REDUCE THE VARIABILITY OF CROP YIELDS. Mont. Agr. Expt. Sta. Tech. Bul. 575. Apr. 1963.

Four sizes of spring wheat farms in northeast Montana are synthesized so as to have field segments dispersed 0-1 mile, 1-4 miles, 4-7 miles, 7-10 miles, 10-15 miles, and 20-25 miles. Yield variability in each year is compared to each dispersion to determine in which years dispersion significantly reduced crop yield variability. Then the yield variability for a series of years (1937-56) for each dispersion group is compared to show variability of yields through time. Variability of a dispersion group is measured in terms of the differences in yield from one farm to another within the group. Tests of significance are made for all differences in yield variability. (15)

Lin, Hildreth, and Tefertiller. NON-PARAMETRIC STATISTICAL TESTS FOR BUNCHINESS OF DRYLAND CROP YIELDS AND REINVESTMENT INCOME. Jour. Farm Econ. 45(3):592-598, illus. Aug. 1963.

Cotton and grain sorghum yields and reinvestment income at constant prices for 1916-55 were tested for bunchiness and for year-to-year persistence. Two nonparametric tests for randomness, the Wallis-Moore and the Wald-Wulfowitz, were used. Runs of years are defined as (1) any change in direction, (2) standard deviation of 0.3, (3) standard deviation of 0.5, (4) standard deviation of 0.8, (5) change in direction of 4-year moving average. (28)

Martin, Lagrone, Plaxico, and Connor. EFFECT OF CHANGES IN PRODUCT PRICE RELATIONSHIPS ON FARM ORGANIZATION AND INCOME--CLAY SOIL FARMS, SOUTHWESTERN OKLAHOMA. Okla. Agr. Expt. Sta. Bul. B-621. Jan. 1964.

Optimum enterprise combinations are determined for a representative, 1,280-acre dryland farm. Thirty production and income budgets are developed, based on 5 prices for cotton lint (13.2, 17.6, 22.0, 26.4, and 30.8 cents), 3 prices for wheat and beef cattle (base price, 30 percent above, and 30 percent below) and two charges for capital (6 and 18 percent interest). Method, assumptions, basic input-output data, example budgets and final results are presented. (17)

Orazem, Hajda, and Bell. IMPLICATIONS OF PROJECTED CHANGES IN FARMING OPPORTUNITIES IN WESTERN KANSAS. Kans. Agr. Expt. Sta. Bul. 452, Dec. 1962.

The probable supply of and demand for farming opportunities are analyzed in four type-of-farming areas individually and in combination by 5-year periods up to 1975. Separate projections assume (1) current trend increase in size of farm and 1.3 operators per farm, (2) same but with 1.5 operators per farm, (3) current trend increase in size of farm, and (4) same but with current trend increase doubled. Projections of farming opportunities by 5-year intervals to 1975 are presented and appraised. Seven factors affecting the supply of, and three affecting the demand for, farming opportunities are discussed. (18)

Orazem and Herring. ECONOMIC ASPECTS OF THE EFFECTS OF FERTILIZERS, SOIL MOISTURE AND RAINFALL ON THE YIELDS OF GRAIN SORGHUM IN THE "SANDY LANDS" OF SOUTHWEST KANSAS. Jour. Farm Econ. 40(3):697-708, illus. Aug. 1958.

Effect of soil moisture at seeding time, rainfall during the growing season, and rates of nitrogen and phosphorous fertilization on grain sorghum yield is analyzed. Data are from farmers who cooperated with the Kansas Agricultural Experiment Station in 1951-56. The experiment included 14 fertilizer treatments and 8 moisture levels, with 4 or 5 replicates per treatment--382 observations in all. (32)

Rodewald. CROP INSURANCE IN MONTANA. Mont. Agr. Expt. Sta. Cir. 235. Nov. 1961.

Data from a survey of dryland farmers who were insurance users and nonusers is analyzed to determine farmers' use of crop insurance, its cost, the insurance coverage, costs of crop production, and the attitudes of users and nonusers toward all-risk and crop-hail insurance. The relative ranking by sample farmers of alternative means of income protection is shown. Different kinds of insurance are discussed as are the hazards faced by dryland farms. (20)

Rodewald, Larson, and Myrick. DRYLAND GRAIN FARMS IN MONTANA. HOW THEY STARTED, GROWTH, AND CONTROL OF RESOURCES. Mont. Agr. Expt. Sta. Bul. 579 (tech.), 47 pp., illus. July 1963.

Two hundred dryland farms surveyed in north-central and northeastern Montana are grouped by size, type, tenure of operator and year started (1910-40, 1940-50, and 1950-60). For each group, present status is compared with beginning size, capital assets and tenure. Then five common sizes of cash-grain farms are each budgeted as full-owner, part-owner, and full-tenant operated with limited equity (land 20 percent, machinery 30 percent) to determine capital requirements, measure probable rates of capital accumulation, and determine debt repayment ability. (21)

Schaffner, Loftsgard, and Dahl. INTEGRATING IRRIGATION WITH DRYLAND FARMING. N. Dak. Agr. Expt. Sta. Bul. 433. May 1961.

Information from interviews with 64 irrigation farmers on the Lower Yellowstone Irrigation Project is reported and analyzed, including size of farm, farm organization, acreage irrigated and dry farmed, sources of farm income, labor requirements, types of livestock feeding, feed utilization, and so on. Optimum plans are developed for a 640-acre farm model with 480 acres of cropland, of which 160 acres could be irrigated. Sixty-four crop and livestock enterprises are considered--44 crop rotations for dryland, 12 for irrigation and 8 enterprises for livestock. Resource restrictions include land, wheat allotment, irrigable acres, feed grains, and hay in addition to operating capital. Results indicate priority of enterprises, depending upon available funds for investment. (22)

Schaffner, Loftsgard, and Vockrodt. PRODUCTION AND INCOME VARIABILITY FOR FARM ENTERPRISES ON IRRIGATION AND DRYLAND. N. Dak. Agr. Expt. Sta. Agr. Econ. Bul. 445 (tech.), June 1963.

Year-to-year variability of dryland crops, irrigated crops, and livestock are analyzed in western North Dakota for the period 1931-59. Data are from a survey of farmers on the Lower Yellowstone Irrigation Project, project yield records, and a survey of

dryland farms. Enterprises include seven dryland crops (wheat, barley, oats, flax, corn silage, alfalfa, wild hay), five irrigated crops (wheat, barley, oats, corn silage, alfalfa) and five livestock (beef-cattle, dairy, hogs, and ewe flock lamb feeding). For each enterprise are computed the mean, the variance, standard deviation, and coefficient of variation for yield, prices, gross income, and net income per $100 of all costs. Correlations are computed between enterprises for output, prices and income. (23)

Tefertiller and Hildreth. IMPORTANCE OF WEATHER VARIABILITY ON MANAGEMENT DECISIONS. Jour. Farm Econ. 43(5):1163-1169. Dec. 1961.

Discusses influence of climate--temperature, rainfall, moisture-temperature relationships and hail and sand storms--on crop yields. Discusses the probability of bunchiness or runs of good or bad crop years, the goals of Plains farmers, the impact of weather variability on farmers' decisions, and a suggested strategy to meet weather variability in Great Plains farming. (36)

Wearden and Orazem. YIELD VARIABILITY AS EXPLAINED BY VARIANCE COMPONENTS. Kans. Acad. Sci. Trans. 63(2):77-84. Summer 1960.

A mathematical model for measuring the total variance and apportioning it among component causal variables is presented. Use of the model including computations is demonstrated by use of 41 years' data on grain sorghum yields in 29 counties distributed among three type-of-farming areas. Variance due to area, to county, and to years is computed. The component variable year could be further broken down into such variables as varieties, dates of planting, rainfall, hail, insect damage and other hazards. (37)

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